FEAS Survey Series: 2014/04

Northwest Herring Acoustic Survey Report

22nd June – 12th July, 2014

RV Celtic Explorer

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1 Introduction

The northwest and west coast (ICES Divisions VIaS & VIIb, c) herring acoustic survey programme was first established in 1994. Prior to acoustic estimation, a larval survey programme was conducted from 1981-1986. In the early 1990s, the ICES herring working group (HAWG) identified the need for a dedicated herring acoustic survey in this area (Anon, 1994). From 1994 to 1996 surveys were carried out on this stock during the summer feeding phase. In 1997 a two-survey spawning survey was established covering both autumn and winter components. In 2004, this was modified to a single spawning stock survey which was carried out early in quarter 1 and continued until 2007. In 2008, it was decided that this survey should be incorporated into the larger coordinated Malin shelf summer survey on recommendation from SGHERWAY and HAWG.

The summer 2014 survey represents the seventh in the new time series (est. in 2008). The survey was coordinated through the ICES Working Group of International Pelagic Surveys (WGIPS). The Irish component was carried out to cover the statistical rectangles between 53°30'-58°30' N and 12°-5° W as laid out in the WGIPS report (ICES, 2014). Combined survey data on herring distribution, abundance and age are used to provide a measure of the relative abundance of herring within the Malin shelf stock complex. Survey data on stock numbers at age are submitted to the ICES Herring Assessment Working Group (HAWG) and used in the annual stock assessment process.

The northwest and west coast (ICES Divisions VIaS & VIIb) herring stock is composed of two spawning components, autumn and winter spawners. Spawning covers a large geographical area and extends over a 4-month period from late September through to late March (Molloy *et al*, 2000). Traditionally, fishing effort has been concentrated on spawning and pre-spawning aggregations. The autumn spawning component, which mostly occurs within VIIb and VIaS, feeds along the shelf break area to the west of the spawning grounds. The larger winter spawning component is found further north in VIa. In VIaS, summer distribution extends from close inshore to the shelf break. Components of the winter spawning fish are known to undertake northward feeding migration into VIaN before returning in the winter to spawn along the Irish coast.

2 Materials and Methods

2.1 Scientific Personnel

Name	Institute	Capacity
Marcin Blaszkowski	FEAS	Biologist
Andrew Campbell	FEAS	Acoustic
Helen McCormick	FEAS	Biologist
Eugene Mullins	FEAS	Acoustic
Cormac Nolan*	FEAS	Acoustic
Brendan O'Hea	FEAS	Acoustic
Tobi Rapp	FEAS	Biologist
Gary Robinson	GMIT	TTRS**
Mairead Sullivan	FEAS	Biologist

* Chief scientist
** SMART Training Through Research Surveys Scheme

2.2 Survey Plan

2.2.1 Survey objectives

The primary objectives of the survey are listed below:

- Carry out a pre-determined survey cruise track based on the known summer herring distribution
- Collect biological samples from directed trawling on fish echotraces to determine age structure and maturity state of survey stock
- Determine an age stratified estimate of relative abundance and biomass of herring within the survey area (ICES Divisions VIIb & VIaS-N) using acoustic survey techniques
- Collect physical oceanography data as horizontal and vertical profiles from a deployed sensor array.
- Collect detailed morphometric data on individual herring to contribute to stock discrimination studies for SGHERWAY
- Collect acoustic and biological data on boarfish (*Capros aper*) to feed into the Boarfish Acoustic Survey, 2014.
- Collect surface water samples for the CaNDyFloSS project (Carbon and Nutrient Dynamics and Fluxes Over Shelf Systems)

2.2.2 Area of operation and survey design

The survey focused on the northwest and west coast of Ireland and the west coast of Scotland (ICES Divisions VIaN & VIaS and VIIb) as shown in Figure 1. The survey track started to the southeast of the Isle of Coll, zigzagged north through the Minches (between the

Scottish mainland and the Hebrides), then worked progressively southwards in parallel east-west transects, before finishing near the mouth of Killary Harbour.

A systematic parallel transect design was adopted for the majority of the survey, with a randomised start point. Transects were positioned running parallel to the lines of latitude and were generally positioned between the 30 m and 250m depth contours. Transect spacing was set at 7.5 nmi in the main body of the survey and at 15 nmi between 57° and 58.5°N. A zigzag design was utilised in the Minches region.

To keep in line with existing survey methodology acoustic data collection was only undertaken during daylight hours (04:00 and 00:00).

In total, the survey covered roughly 3,000nmi, 2,301nmi of which were on transect and suitable for acoustic integration. Survey design and methodology adheres to the methods laid out in the WGIPS acoustic survey manual (2015).

2.3 Equipment and system details and specifications

2.3.1 Acoustic array

Equipment settings (Table 1) were determined before the start of the survey and are based on established settings employed on previous surveys (O'Donnell *et al.,* 2004 and 2008).

Acoustic data were collected using the Simrad EK60 scientific echosounder. A Simrad ES-38B (38 kHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3.3 m below the vessels hull or 8.8 m below the sea surface. Data were also collected at operating frequencies of 18, 120 and 200 kHz during the survey. Estimates of herring abundance and biomass were derived exclusively from 38 kHz data.

While surveying on track, the vessel is powered using DC twin electric motor propulsion system with power supplied from 1 main diesel engine, so in effect providing "silent cruising" as compared to normal operations (Anon, 2002). Cruising speed is maintained at a maximum of 10Kts (knots) where possible. During fishing operations, normal 2 engine operations were employed to provide sufficient power to tow the net.

2.3.2 Calibration of acoustic equipment

The EK60 was calibrated in Killary Harbour on the 23nd of June before commencing the survey to ensure optimal operation of the echosounder during data logging. A second calibration could not be performed at the end of the survey due to time constraints. The results of the 38 kHz calibration are presented in Table 1. Prior to the survey, the EK60 was last calibrated in April 2014.

2.3.4 Acoustic data acquisition

Acoustic data were recorded onto the hard-drive of the EK60 processing PC. The raw ER60 files were copied via a continuous ethernet connection to the vessels server as a backup in the event of system failure. Further back-up copies were stored on an external HDD and magnetic LTO4 tapes. Myriax Echoview Echolog (Version 4.8) live-viewing software was used to display the echogram during data collection to allow the scientists to monitor target locations and depths of fish shoals in almost real-time. A member of the scientific crew monitored the equipment continually. Time and position were recorded for each transect start/end point within each stratum. The log was also used to record "off track events" such as fishing operations and hydrographic stations.

2.3.5 Echogram scrutinisation

Acoustic data was backed up every 24 hrs and scrutinised using Myriax Echoview (vers. 5.3). The scrutiny process involved the allocation of echotraces (schools) to particular species or species mix categories, based on information from the directed trawl hauls and the schools characteristics and location.

The NASC (Nautical Area Scattering Coefficient) values from each herring echotrace were allocated to one of 4 categories after scrutiny of the echograms. Categories identified on the basis of echotrace scrutiny were as follows:

1. "Definitely herring" echotraces or traces were identified on the basis of captures of herring from the fishing trawls that had sampled the echo-traces directly, and on large echotraces which had the characteristics of "definite" herring traces (i.e. very high intensity (red), narrow inverted tear-shaped marks either directly on the bottom or in mid-water and in the case of spawning shoals very dense aggregations in close proximity to the seabed).

2. "Probably herring" were attributed to smaller echotraces that had not been fished but which had the characteristic of "definite" herring traces.

3. "Herring in a mixture" were attributed to NASC values arising from all fish traces in which herring were thought to be contained, owing to the presence of a proportion of herring within the nearest trawl haul or within a haul which had been carried out on similar echotraces in similar water depths.

4. "Possibly herring" were attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite herring traces.

Echograms were divided into transects, and off track events, including trawl hauls and hydrographic stations, were excluded from further analysis. Echo integration was performed on regions that were defined by enclosing selected parts of the echogram that corresponded to one of the four categories above. The echograms were generally analysed and echo-integrals calculated at a threshold of -70 dB; where necessary heavy backscatter from plankton was filtered out by thresholding at –65 dB.

2.3.6 Biological sampling

A single pelagic multipurpose midwater trawl with the dimensions of 54m in length (LOA) and 8m at the wing ends and a fishing circle of 420m was employed during the survey (Figure 13). Mesh size in the wings was 2.2m through to 4cm in the cod-end. The net was fished with a vertical mouth opening of between 16m and 20m, which was observed using a cable linked "BEL Reeson" netsonde (50 kHz). Spread between the trawl doors was monitored using Scanmar distance sensors, all sensors being configured and viewed through a Scanmar Scanbas system.

All components of the catch from the trawl were sorted; fish and other taxa were identified to species level. Fish samples were segregated by species and each component weighed. For species other than herring, length and weight measurements were taken for 100 individuals in addition to a 300 fish length frequency sample. Age, length, weight, sex, and maturity data were recorded from 100 random herring, a further 100 random length/weight measurements were also taken, in addition to a 300 fish length frequency sample from each trawl. All herring were aged onboard. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

Decisions to fish on particular echo-traces were largely subjective, though an attempt was made to target all significant fish mark-types throughout the survey grid regardless of subjective eye-ball classifications. No bottom trawl gear was used during this survey.

2.3.7 Oceanographic data collection

Hydrographic stations were carried out during the survey at predetermined locations along the track. Data on temperature, depth and salinity were collected using a Seabird 911 sampler from 1 m subsurface to full depth.

Surface water samples were also collected for the CaNDyFloSS project (Carbon and Nutrient Dynamics and Fluxes over Shelf Systems). One of the aims of this project is to quantify how much carbon is exported from the NW European shelf. Therefore daily nutrient and carbonate chemistry samples were taken from 5m depth at hydrographic stations close to the shelf edge. Each daily sample was stored and preserved for three different types of analyses: dissolved inorganic carbon, nutrients, and dissolved organic matter. More information on the CaNDyFloSS project can be found here: **http://bit.ly/1ofNGdp**

2.3.8 Marine mammal and seabird survey

Marine mammal and seabird sighting surveys were not carried out during this survey.

2.4 Analysis methods

2.4.1 Abundance estimates

The recordings of area back scattering strength (NASC) per nautical mile were averaged over a one nautical mile EDSU (Elementary sampling distance unit), and the allocation of NASC values to herring and other acoustic targets was based on the composition of the trawl catches and the appearance of the echotraces.

To estimate the abundance, the allocated NASC values were averaged for ICES statistical rectangles (1° latitude by 2° longitude). For each statistical area the unit area density of fish (S_A) in number per square nautical mile ($N*nmi^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al*. 1998).

NASC values assigned according to scrutinisation methods (section 2.3.5) were used to estimate the boarfish numbers according to the method of Dalen and Nakken (1983).

The following TS-length relationships used were those recommended by the acoustic survey planning group (ICES, 1994):

Herring	TS =	$20\log_{10}L - 71.2$ dB per individual (L = length in cm)
Sprat	TS =	$20\log_{10}L - 71.2$ dB per individual (L = length in cm)
Mackerel	TS =	$20\log_{10}L - 84.9$ dB per individual (L = length in cm)
Horse mackerel	TS =	$20\log_{10}L - 67.5$ dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids	TS =	$20\log_{10}L - 67.4$ dB per individual (L = length in cm)

For boarfish (*Capros aper*) a species specific TS length relationship was applied based on theoretical swimbladder modelling (Fässler *et al.* 2013).

Boarfish	TS =	$20\log_{10}L - 66.2$ dB per individual (L = length in cm)

To estimate the total abundance of fish, the unit area abundance for each statistical rectangle was multiplied by the number of square nautical miles in each statistical square and then summed for all statistical rectangles in the total area. Biomass estimation was calculated by

multiplying abundance in numbers by the average weight of the fish in each statistical rectangle and then sum of all squares by rectangle and summed for the total area.

3 Results

3.1 Herring abundance and distribution

Twenty five hauls were carried out during the survey, of which 16 contained herring (Figure 2, Table 2). 2,374 herring lengths were taken, together with 1,663 length/weight measurements and 874 individual age readings. Seven hauls were sampled for the SGHERWAY stock identification project (Figure 2), resulting in 727 body morphometry photographs and otoliths for shape analysis.

3.1.2 Herring biomass and abundance

Total herring abundance, biomass and SSB for the whole area surveyed by the Celtic Explorer are summarised in the table below.

	Abund. (millions)	Biomass (t)	% Contribution
All herring			
Def Herring	792	157,063	54
Herring in a mix	53	6,713	2
Probably Herring	1,543	130,393	44
Possibly Herring	308	45,596	
Total excl. poss.	**2,388**	**294,169**	
Spawning stock			
Def Herring	776	154,797	77
Herring in a mix	19	3,393	2
Probably Herring	224	41,989	21
Possibly Herring	191	32,974	
Total excl. poss.	**1,019**	**200,174**	

The total stock biomass was estimated at 294,169 t, which is a 247% increase from the very low 2013 estimate of 118,879 t. There was a similar increase in SSB to 200,174 t.

The overwhelming majority of herring were observed in ICES area VIaN: total herring biomass (TSB) was 279,100 t, total herring abundance (TSN) was 2,267 million individuals, and spawning stock biomass (SSB) was 191,600 t.

TSB was 15,100 t in ICES areas VIaS, VIIb and c, the TSN was 120 million individuals, and the SSB was 8,600 t. All less than half the 2013 estimate.

A full breakdown of the survey stock structure by strata, age, length, maturity and area is presented in Tables 4-8.

3.1.3 Herring distribution

In total, 455 herring echotraces were recorded during the survey (Table 9), the majority were 'Probably Herring' in VIaN (Figure 3). Large herring schools were primarily located in two distinct areas between the shelf-break and 8° W, one near St. Kilda and one in stat rectangle 42E1 (Figure 3), as in previous years. However, the stat rectangle containing the greatest biomass of herring was 41E3, south of Coll and Tiree. A number of very large schools were observed in the rectangle and a reliable sample (haul 16) showed 97% of one school was herring. In contrast to 2013, a number of probable herring schools were seen in the Minches region but the largest two marks proved unfishable due depth and bottom topography. They

were labelled as 'probably herring' due to their mark characteristics and the occurrence of a small number of herring in a nearby haul. Some large schools were also observed to the west and north-west of Donegal. Overall the number of large schools seen in 2014 (20 with a NASC > 1,000) was far greater than the previous year (7) and more comparable to 2012 (28).

The majority of herring occurred in large, discrete schools in close proximity to the seabed (see Appendix 1; e.g. Hauls 6, 8, 9, 13 and 16) or in mixed-species assemblages, forming a light scattered layer along the seabed with mackerel and demersal species (Table 2; Appendix 1 Hauls 2, 10, 20 and 25). These layers often extended for several miles. No herring schools were observed in the upper regions of the water column. The number and size of herring schools was quite different to 2013 and resembled the more 'normal' 2012 survey (Figure 3 and Appendix 1).

Similar to previous surveys, very few herring were observed in VIIb. Those that were, were seen in small schools mixed with a number of other species (Table 5, Figure 3).

3.1.4 Herring stock structure

Age analysis of biological samples showed herring within the survey area to be composed of age-groups from 1-9 years (winter rings; Tables 4-6). In 2013, the stock age profile was dominated by 3- and 4-ring herring in terms of biomass and abundance. These cohorts were evident again in 2014, representing 23% of the total biomass as 4-ringers and 25% as 5-ringers (16% and 15% respectively of the total abundance; Tables 5 and 6). 1,115 million herring (47% of the total abundance) were estimated to be 1-ringers. Inspection of the haul composition and length-frequency data show that the high proportion of 1-ringers can be attributed to two hauls (hauls 3 and 16) and a number of nearby schools that these hauls were assigned to in the Minches region and south of Coll and Tiree.

Combined maturity analysis indicated that the majority of herring encountered during the survey were (57% of the TSN) were immature (32% of the TSB, Tables 7 and 8). In contrast, over half the estimated TSN were spent during the 2013 survey. This reflects the apparent large influx of 1-ringers in 2014 and the complete lack of 1-ringers in 2013. The smallest herring sampled were 16cm in length (Table 3), compared to 21cm in 2013 and 17cm in 2012.

3.2 Other Pelagics

3.2.1 Boarfish

Boarfish (*Capros aper*) were encountered from 70-140 m and were found exclusively close to the shelf-break (Figure 4). The majority of the boarfish that was detected acoustically occurred in small or medium sized schools close to bottom (see Appendix 1; Haul 7 and 11).

Overall, 745 individual length measurements and 300 length/weight measurements were recorded from three hauls. Boarfish length ranged from 12.5-18 cm (Figure 5) with a corresponding weight range of 37-101 g. Mean length was 14.4 cm and mean weight 63 g.

Estimates of boarfish abundance and biomass are not reported here because the data were combined with those collected over a much wider area as part of a dedicated boarfish acoustic survey (see O'Donnell and Nolan, 2014).

3.2.2 Sprat

Sprat were caught in hauls 3 and 14 (Figure 2; Appendix 1). As in previous years, sprat were recorded on the eastern edges of the survey coverage, south of Coll and north of Ireland (Figure 4). Sprat are weighed and measured as part of the biological sampling but are not aged. The table below shows the estimated abundance and biomass of sprat for the entire survey area in 2014. A further breakdown is presented in Table 12.

	Abund. (millions)	Biomass (t)	% Contribution
Definitely Sprat	160	1,939	19
Probably Sprat	670	8,099	81
Total	**830**	**10,038**	

3.2.3 Mackerel

Mackerel were encountered in most hauls, occasionally making up over 90% of the total catch. They were distributed over the entire survey area, usually as mixed species scattering layers.

In total 478 individual lengths and 339 length/weight measurements were recorded for mackerel from 14 hauls. Length ranged from 7-40 cm with a corresponding weight range of 3-562 g. Mean length was 28 cm and mean weight 212 g.

3.3 Oceanography

A total of 45 CTD casts were made during the survey (Figure 1). All data were compiled to produce horizontal plots of temperature and salinity at the following depths; 5m, 20m, 40m and 60m subsurface (Figures 6-9). 20 sets of water samples were preserved for the CaNDyFloSS project.

The hydrographic data showed that, similar to previous years, the upper regions of the water column (5 & 20 m) in VIaS (northwest Ireland) were considerably warmer than the VIaN region (c. 14.5 ℃ cf. 11.5 ℃ north of 57°N; Figure 6 and 7). On average, the surface waters were roughly 0.5 ℃ warmer than the same time last year. At 40 and 60 m, the water temperature was much cooler throughout most of the survey sector (c. 10.5 ℃), indicating that the water was well-stratified thermally in most regions (Figure 9). Unlike the 2013 survey, the temperature profile north of Mayo also seemed to show a stratified water column (between 5 and 60 m). Our results again showed that generally the water salinity decreased gradually from the shelf-break (c. 35.4 ppt) towards land (c. 34 ppt) at all depths surveyed through the survey region (Figures 6-9). Salinity was fairly uniform throughout the water column, varying by approximately 0.1 to 0.5 ppt between the upper layers and 60 m with the more saline water extending slightly further eastward at 60m.

In general, the spatial pattern of temperature variation in 2014 was similar to that in 2013, with coastal waters around northwest Ireland being predominantly warmer than those in the northern and shelf-break regions. One difference, however, was that the pool of cold water (< 10℃) found at 60m in 2013 was divided in two in 2014 (Figure 9) by an area of slightly warmer water (>10.5 ℃) between 55° N and 56°N.

4 Discussion and conclusions

4.1 Discussion

All components of the work program were completed as planned. The estimates of biomass and abundance had acceptable degrees of precision, with CVs of 28.6% and 38.8% respectively, and the acoustic analyses were supported by a high number of trawl hauls. All four frequencies of the EK60 echosounder were calibrated successfully prior to beginning the planned cruise track but no inter-calibration with the MFV Felluca could be conducted before the start of the boarfish acoustic survey due to time constraints.

The time series of the Irish portion of the MSSHAS (Table 11) is highly variable but a more accurate estimate of the overall Malin Shelf herring population will emerge when the results of the current survey are added to those of concurrent Marine Scotland survey at the next WGIPS meeting (January 2015). That said, estimated total stock biomass has increased roughly 240% over the 2013 TSB estimate, which in turn was a 70% decrease from 2012. 2013 seems to have been an anomalous year, with very few large feeding aggregations of herring, possibly due to weather conditions (Nolan *et al*., 2013). The current survey saw a return to the large, dense, mid-water schools of previous years and a TSB estimate more in line with 2010-2012 levels. However, as the current biomass/abundance estimates are based on fewer but larger marks, the coefficients of variation around the estimates are higher than 2013, particularly for abundance since almost half of the TSN were small, light, 1-ringers that contributed less to the biomass.

At least two stocks of herring mix in the survey area in the summer months (WESTHER Final Report). Work is ongoing to produce separate survey indices for herring of West of Scotland (VIaN) and West of Ireland (VIaS/VIIbc) origin. This involves body and otolith morphology recorded according to SGHERWAY protocol and subsequent discriminant analyses. In the meantime, splitting the two stocks purely geographical as has been done in the past (along the 56° N line) shows that the VIaS/VIIbc area had the lowest TSB in its time series, one third that of 2013 (15 kt, Table 10). However, a purely geographical split is now widely considered as inappropriate.

No 1-ringed herring were sampled during the 2013 survey. In stark contrast, 47% of the 2014 survey abundance was attributed to 1-ringers. In the past this survey has not reliably quantified 1-ringed herring and apparently large incoming year classes are not always observed in the subsequent year. Very young fish are almost exclusively caught in the Minches region and it seems to be quite 'hit and miss' for this age group probably because West of Scotland bays are not fully covered. This year two hauls (2 and 16) in the Minches region caught very small, juvenile herring (Table 3) and these hauls were assigned to a number of large, unsampled schools close by. This was the cause of the 47% 1-ringer abundance estimate and the large abundance CV as mentioned above.

The occurrence of huge, dense schools of juvenile blue whiting to the north-west and west of Donegal (Figure 4) made the task of scrutinising the echograms more complicated. These schools often had almost identical acoustic characteristics as herring marks (*e.g.* haul 18, appendix 1) and were highly mobile, proving quite difficult to capture with the small, mid-water trawl (see hauls 17, 18, 20 and 22, appendix 1). Even when parts of these large marks were seen passing between the footrope and headline, via the headline transducer, the juvenile blue whiting were so small that they apparently passed through the meshes, leaving a mere 50kg of fish in the cod-end. Some un-sampled schools in the area looked very similar to herring schools and were therefore labelled as 'possibly herring' but it should be stressed that, despite multiple attempts, no trawl samples provided adequate evidence that herring were present in the area in such numbers. No dubious marks were labelled as definitely or probably herring. It is safer to assume the 43,000 t of 'possibly herring' are just that: possibly herring but more likely juvenile blue whiting. Since the final estimate is based on the definitely, probably and mix categories only, its accuracy is not in doubt.

4.2 Conclusions

- The Irish portion of the Malin Shelf Summer Herring Acoustic Survey was completed successfully and robust estimates of herring abundance (2,388 mill.) and biomass (TSB 294k t) were calculated.

- There was a ~250% increase in TSN, TSB, SSN and SSB over the low 2013 estimate. The true extent of the increase will not be apparent until these results are combined with those from Marine Scotland at the next WGIPS meeting.

- The vast majority of herring were distributed within ICES area VIaN. VIaS saw a further reduction in biomass and very few herring schools were observed in VIIb. Although a purely geographical split is inappropriate.

- Six herring hauls were sampled, using the SGHERWAY protocol, for later stock discrimination.

- The survey successfully tracked the 2009 and 2010 year classes. Almost 47% of herring sampled were one ringers; possibly a sign of good recruitment but estimates are not considered completely reliable for this age group (see discussion).

- CTD data indicated that coastal waters around northwest Ireland were warmer than those in the northern and shelf-break regions and were overall about 0.5 ºC warmer than the same time the previous year. The majority of herring seemed to be concentrated near a pool of cold water (< 10℃), 40-60m deep, west of Barra (between 8° and 9° West) but in-depth analyses of the correlations between temperature and herring distribution were not performed.

- Boarfish data was recorded and added to the coverage of the 2014 boarfish acoustic survey.

- Sprat data will be presented at the next WGIPS meeting.

- An unusual amount of juvenile blue whiting was observed west and north-west of Donegal.

5 Acknowledgements

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Table 1. Survey settings and calibration report (38kHz) for the Simrad ER60 echosounder. Northwest herring survey, June\July 2014.

```
# Calibration  Version   2.1.0.12
#
# Date:  6/23/2014
#
# Comments:
#   Killary, Cu sphere
#
# Reference Target:
#   TS               -33.50 dB       Min. Distance         15.00 m
#   TS Deviation       5.0 dB        Max. Distance         20.00 m
#
# Transducer:  ES38B  Serial No.   30227
#   Frequency          38000 Hz      Beamtype               Split
#   Gain              25.98 dB       Two Way Beam Angle   -20.6 dB
#   Athw. Angle Sens.      21.90      Along. Angle Sens.      21.90
#   Athw. Beam Angle     7.00 deg      Along. Beam Angle    6.93 deg
#   Athw. Offset Angle  -0.03 deg      Along. Offset Angle -0.06 deg
#   SaCorrection        -0.69 dB       Depth                8.80  m
#
# Transceiver:  GPT  38 kHz 009072033933 1-1 ES38B
#   Pulse Duration       1.024 ms      Sample Interval     0.192   m
#   Power              1600  W        Receiver Bandwidth   2.43 kHz
#
# Sounder Type:
#   EK60 Version  2.4.3
#
# TS Detection:
#   Min. Value         -50.0 dB       Min. Spacing          100 %
#   Max. Beam Comp.      6.0 dB       Min. Echolength        80 %
#   Max. Phase Dev.      8.0          Max. Echolength       180 %
#
# Environment:
#   Absorption Coeff.   9.2 dB/km      Sound Velocity     1503.7 m/s
#
# Beam Model results:
#   Transducer Gain    = 25.92 dB      SaCorrection      = -0.66 dB
#   Athw. Beam Angle   = 6.98 deg       Along. Beam Angle  = 6.94 deg
#   Athw. Offset Angle =-0.05 deg       Along. Offset Angle=-0.05 deg
#
# Data deviation from beam model:
#   RMS =    0.11 dB
#   Max =    0.30 dB  No. =   151  Athw. = -2.6 deg  Along = -3.3 deg
#   Min =   -0.45 dB  No. =   121  Athw. =  3.6 deg  Along = -3.7 deg
#
# Data deviation from polynomial model:
#   RMS =    0.06 dB
#   Max =    0.13 dB  No. =   151  Athw. = -2.6 deg  Along = -3.3 deg
#   Min =   -0.17 dB  No. =    99  Athw. = -3.8 deg  Along = -2.8 deg
```

Table 2. Catch composition and position of hauls undertaken by the RV *Celtic Explorer.* Northwest herring survey, June\July 2014. Latitude and longitude in decimal degrees.

No.	Date	Time	Lat.	Lon.	Target Depth	Bottom Depth	Bulk Catch	Sampled Catch	Herring	Boarfish	Mackerel	Jellyfish	Others^
			N	W	(m)	(m)	(kg)	(kg)	%	%	%	%	%
1	25/06/2014	08:52	57.500	-7.000	140	166	57.9	57.9	4.2	0.0	0.4	12.8	82.6
2	25/06/2014	18:54	58.000	-6.000	63	68	119.7	119.7	9.0	0.0	0.0	87.3	3.7
3	26/06/2014	08:05	58.400	-5.900	93	98	49.4	49.4	0.2	0.0	0.8	10.5	88.5
4	26/06/2014	18:18	58.500	-6.900	65	70	21.5	21.5	0.0	0.0	0.0	16.7	83.3
5	27/06/2014	13:21	58.200	-7.700	24	54	10.8	10.8	0.0	0.0	91.4	8.6	0.0
6	27/06/2014	21:00	58.000	-8.200	130	135	4000.0	213.8	100.0	0.0	0.0	0.0	0.0
7	28/06/2014	08:07	57.700	-9.400	140	150	88.0	88.0	2.3	92.7	4.7	0.4	0.0
8	28/06/2014	10:59	57.700	-9.000	130	140	7000.0	192.4	98.5	0.0	1.5	0.0	0.0
9	29/06/2014	19:04	57.000	-8.600	121	126	750.0	198.2	100.0	0.0	0.0	0.0	0.0
10	30/06/2014	06:04	56.800	-8.200	118	123	750.0	187.1	99.7	0.0	0.0	0.0	0.3
11	30/06/2014	15:53	56.600	-9.000	134	139	500.0	126.4	0.0	95.1	2.9	0.3	1.7
12	01/07/2014	07:38	56.500	-8.200	100	150	2.6	2.6	0.0	0.0	17.8	64.4	17.9
13	01/07/2014	09:25	56.500	-8.300	147	152	160.6	160.6	94.3	0.0	0.3	0.0	5.4
14	01/07/2014	21:36	56.300	-8.900	47	67	25.4	25.4	1.8	0.0	0.0	2.4	95.8
15	02/07/2014	20:25	56.100	-8.400	140	145	6.9	6.9	69.9	0.0	0.0	3.8	26.3
16	03/07/2014	06:57	56.100	-7.000	50	69	2000.0	180.3	96.8	0.0	0.3	0.0	2.9
17	04/07/2014	11:19	55.800	-8.500	98	123	55.0	33.1	0.0	0.0	0.0	0.0	100.0
18	05/07/2014	08:43	55.700	-8.800	75	95	0.0	0.00.0	0.0	0.0	0.0	0.0	
19	05/07/2020	12:45	55.700	-9.300	127	137	48.9	48.9	0.0	99.4	0.0	0.2	0.5
20	06/07/2014	08:19	55.300	-8.500	67	87	107.0	107.0	53.1	0.0	46.6	0.1	0.2
21	08/07/2014	05:33	55.100	-9.500	65	105	0.0	0.00.0	0.0	0.0	0.0	0.0	
22	08/07/2014	06:52	55.100	-9.500	54	104	50.7	50.7	6.6	0.0	1.3	0.7	91.4
23	08/07/2014	18:28	55.000	-9.900	105	115	31.4	31.4	0.0	0.0	75.3	13.3	11.5
24	09/07/2014	09:15	54.500	-10.300	109	109	10.7	10.7	1.8	0.0	94.4	1.1	2.6
25	11/07/2014	14:03	53.700	-10.200	82	87	10.8	10.8	36.7	0.0	16.2	11.2	36.0

Table 3. Length-frequency of herring hauls used in the analysis. Northwest herring survey, June\July 2014.

Length (cm)	Haul 2	Haul 6	Haul 8	Haul 9	Haul 10	Haul 13	Haul 16	Haul 20	Haul 25
16	8	-	-	-	-	-	1	-	-
16.5	11	-	-	-	-	-	1	-	-
17	25	-	-	-	-	-	6	-	-
17.5	37	-	-	-	-	-	1	-	-
18	41	-	-	-	-	-	6	-	-
18.5	22	-	-	-	-	-	12	-	-
19	8	-	-	-	-	-	23	-	2
19.5	4	-	-	-	-	-	27	-	-
20	3	-	-	-	-	-	27	1	-
20.5	6	-	-	-	-	-	21	-	2
21	2	-	-	-	-	-	8	3	2
21.5	1	-	-	-	-	-	8	5	2
22	1	-	-	-	-	-	4	12	2
22.5	2	-	-	-	-	-	2	15	5
23	7	-	-	-	-	1	-	14	4
23.5	1	-	1	-	-	1	1	14	1
24	7	1	-	-	-	2	1	6	1
24.5	2	4	-	1	4	1	-	7	2
25	1	5	2	2	8	6	-	12	1
25.5	-	9	5	15	30	5	1	14	-
26	-	13	4	27	29	16	-	13	4
26.5	-	20	26	28	50	24	-	27	-
27	-	35	27	39	31	27	-	21	1
27.5	-	22	30	27	21	30	-	19	-
28	-	20	33	25	13	33	-	11	2
28.5	-	21	25	19	8	21	-	5	-
29	-	25	25	11	3	19	-	-	-
29.5	-	21	14	4	3	9	-	1	1
30	-	4	8	1	-	2	-	-	1
30.5	-	-	-	1	-	1	-	-	-
31	-	-	-	-	-	2	-	-	-
31.5	-		-	-	-	-	-	-	-
32	-		-	-	-	-	-	-	-
32.5	-		-	-	-	-	-	-	-
Division	**VIaN**	**VIaN**	**VIaN**	**VIaN**	**VIaN**	**VIaN**	**VIaN**	**VIaS**	**VIIb**

Table 4. Herring length at age (winter rings) as abundance (millions) and biomass (000's tonnes). Northwest herring survey, June\July 2014.

Length (cm)	Age 0	(rings) 1	2	3	4	5	6	7	8	9	10	Abund. (mill.s)	Biomass '000's tonnes	Mn Wt (g)
16	-	21.94	-	-	-	-	-	-	-	-	-	21.94	0.8	38.7
16.5	-	29.76	-	-	-	-	-	-	-	-		29.76	1.2	38.4
17	-	73.77	-	-	-	-	-	-	-	-		73.77	3.3	41.9
17.5	-	85.83	-	-	-	-	-	-	-	-		85.83	4.2	44.4
18	-	136.9	-	-	-	-	-	-	-	-		136.89	7.3	49.2
18.5	-	126.9	-	-	-	-	-	-	-	-		126.88	7.4	54.1
19	-	169.3	22.58	-	-	-	-	-	-	-		191.91	12.1	61.5
19.5	-	198.6	-	-	-	-	-	-	-	-		198.6	13.5	66.6
20	-	142.7	-	-	-	-	-	-	-	-		142.69	10.5	73.2
20.5	-	105.2	42.08	-	-	-	-	-	-	-		147.28	11.7	75.4
21	-	24.55	30.69	6.14	-	-	-	-	-	-		61.38	5.2	83.7
21.5	-	-	24.35	10.44	-	-	-	-	-	-	-	34.79	3.2	87.1
22	-	-	13.88	6.94	1.73	-	-	-	-	-	-	22.55	2.2	98.1
22.5	-	-	26.9	3.16	-	-	-	-	-	-	-	30.06	3.2	105.8
23	-	-	15.16	5.05	1.26	-	-	-	-	-	-	21.47	2.4	113.1
23.5	-	-	3.59	7.19	0.72	-	-	-	-	-	-	11.5	1.4	123.3
24	-	-	13.79	5.51	-	-	-	-	-	-	-	19.3	2.5	127.5
24.5	-	-	6.82	5.46	5.46	-	-	-	-	-	-	17.74	2.4	135.0
25	-	-	7.42	7.42	5.77	0.82	-	-	-	-	-	21.43	3.1	144.8
25.5	-	-	4.43	16.63	11.08	1.11	-	-	-	-	-	33.25	5.1	153.2
26	-	-	1.63	19.56	60.32	6.52	-	-	-	-	-	88.03	14.4	163.5
26.5	-	-	1.34	26.7	77.44	12.02	2.67	-	-	-	-	120.17	20.8	172.8
27	-	-	-	28.65	114.6	32.24	1.79	-	-	-	-	177.3	32.5	181.7
27.5	-	-	-	15.77	61.65	45.88	5.73	-	1.43	-	-	130.46	25.3	190.2
28	-	-	-	1.63	32.62	75.02	19.57	4.89	-	1.63	-	135.36	27.8	197.1
28.5	-	-	-	-	7.31	55.57	16.09	2.92	-	-	-	81.89	17.7	205.2
29	-	-	-	-	-	88.38	42.67	3.05	-	-	-	134.1	30.6	215.1
29.5	-	-	-	-	-	26.74	21.73	3.34	1.67	-	-	53.48	12.9	219.0
30	-	-	-	-	-	7.8	11.7	3.9	5.85	-	-	29.25	7.4	222.4
30.5	-	-	-	-	-	-	3.05	-	-	3.05	-	6.1	1.6	217.5
31	-	-	-	-	-	-	-	0.78	0.78	-	-	1.56	0.4	237.3
31.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TSN	-	1115	214.7	166.3	380	352.1	125	18.88	9.73	4.68	-	2386.72	-	-
TSB	-	69.25	20.88	25.5	68.25	74.27	28.15	4.344	2.381	1.148	-	-	294.2	-
Mn Weight	-	55.21	110.4	151.6	174.8	197	208.8	215.9	220.3	225.5	-	-	-	-
Mn Length	-	18.78	23.24	25.69	26.98	28.35	28.99	29.34	29.92	29.6	-	-	-	-

Table 5. Herring biomass (000's tonnes) at age (winter rings) by ICES statistical rectangle and division. Northwest herring survey, June\July 2014.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
45E4	0	0	0	0	0	0	0	0	0	0	0	0
45E3	0	0.5	0.1	0	0	0	0	0	0	0	0	0.7
45E2	0	0.4	0.1	0.3	0.9	1.1	0.4	0.1	0	0	0	3.4
45E1	0	0	0	0	0	0	0	0	0	0	0	0.1
44E4	0	0	0	0	0	0	0	0	0	0	0	0
44E3	0	12.1	2.8	1.1	0.3	0	0	0	0	0	0	16.3
44E2	0	0	0	0	0.1	0.1	0	0	0	0	0	0.2
44E1	0	0	0.6	5.2	18.6	27.1	11	1.7	1	0.4	0	65.5
44E0	0	0	0	0.1	0.5	0.7	0.3	0	0	0	0	1.8
43E3	0	0	0	0	0	0	0	0	0	0	0	0
43E2	0	0	0.1	0.4	1	0.6	0.1	0	0	0	0	2.2
43E1	0	0	0.3	3.8	14	21.5	9.2	1.4	0.9	0.3	0	51.4
43E0	0	0	0	0	0	0	0	0	0	0	0	0
42E3	0	0	0	0	0	0	0	0	0	0	0	0
42E2	0	0	0.1	0.5	1.5	1	0.3	0	0	0	0	3.5
42E1	0	0	0.8	5.4	15.6	9.2	2.3	0.3	0.1	0	0	33.7
42E0	0	0	0	0	0	0	0	0	0	0	0	0
41E3	0	53	11	2.4	0.2	0	0	0	0	0	0	66.6
41E2	0	0.1	0.3	1.3	4.2	3.8	1.3	0.2	0.1	0.1	0	11.4
41E1	0	0	0.5	2.4	7.7	7.1	2.5	0.3	0.2	0.2	0	20.9
41E0	0	0	0	0	0	0	0	0	0	0	0	0
40E3	0	1.3	0.3	0.1	0	0	0	0	0	0	0	1.6
40E2	0	1.3	0.3	0.2	0.4	0.3	0.1	0	0	0	0	2.7
40E1	0	0	0.2	0.2	0.3	0.1	0	0	0	0	0	0.8
40E0	0	0	0	0	0	0	0	0	0	0	0	0
39E2	0	0	0.1	0.1	0.2	0.1	0	0	0	0	0	0.4
39E1	0	0	0.7	0.7	1.2	0.5	0.1	0	0	0	0	3.1
39E0	0	0	0.1	0.1	0.2	0.1	0	0	0	0	0	0.5
39D9	0	0	0	0	0	0	0	0	0	0	0	0
38E1	0	0	0.2	0.2	0.4	0.1	0	0	0	0	0	1
38E0	0	0	0	0	0	0	0	0	0	0	0	0.1
38D9	0	0	0	0	0	0	0	0	0	0	0	0
37E1	0	0	0	0	0	0	0	0	0	0	0	0
37E0	0	0	0.1	0	0.1	0	0	0	0	0	0	0.3
37D9	0	0	0.1	0.1	0.1	0	0	0	0	0	0	0.4
36D9	0	0.4	2.1	1	1.2	0.7	0.4	0.1	0.1	0	0	5.9
36D8	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**69.2**	**20.9**	**25.5**	**68.3**	**74.3**	**28.1**	**4.3**	**2.4**	**1.1**	**0**	**294.1**
%	**0**	**24**	**7.1**	**8.7**	**23.2**	**25.2**	**9.6**	**1.5**	**0.8**	**0.4**	**0**	**100**

VIaN	0	67.5	17	22.9	64.3	72.3	27.4	4.2	2.3	1.1	0	279
VIaS	0	1.3	1.6	1.5	2.6	1.2	0.3	0	0	0	0	8.5
VIIb	0	0.5	2.3	1.1	1.3	0.8	0.4	0.1	0.1	0	0	6.6

Table 6. Herring abundance (millions) at age (winter rings), by ICES statistical rectangle and division. Northwest herring survey, June\July 2014.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
45E4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45E3	0.0	9.9	1.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	11.4
45E2	0.0	8.5	1.2	1.7	4.7	5.3	1.9	0.3	0.1	0.1	0.0	23.8
45E1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3
44E4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44E3	0.0	232.8	25.9	8.9	2.1	0.1	0.0	0.0	0.0	0.0	0.0	269.7
44E2	0.0	0.0	0.0	0.1	0.3	0.3	0.1	0.0	0.0	0.0	0.0	0.9
44E1	0.0	0.0	4.1	29.6	101.0	126.7	48.5	7.5	3.9	1.7	0.0	322.8
44E0	0.0	0.0	0.1	0.7	2.6	3.4	1.4	0.2	0.1	0.0	0.0	8.6
43E3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43E2	0.0	0.0	0.4	2.1	5.8	2.9	0.7	0.1	0.0	0.0	0.0	11.9
43E1	0.0	0.0	2.1	21.6	76.1	100.1	40.2	6.2	3.6	1.3	0.0	250.9
43E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42E3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42E2	0.0	0.0	0.6	2.9	8.3	5.1	1.4	0.2	0.1	0.1	0.0	18.6
42E1	0.0	0.0	5.3	31.7	87.9	45.8	10.8	1.4	0.5	0.2	0.0	183.6
42E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41E3	0.0	816.5	128.8	24.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	971.2
41E2	0.0	1.8	2.2	7.8	23.3	18.4	6.0	0.8	0.4	0.4	0.0	61.1
41E1	0.0	0.0	3.4	14.4	43.0	34.0	11.0	1.6	0.7	0.8	0.0	108.9
41E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40E3	0.0	19.4	3.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.1
40E2	0.0	19.7	3.4	1.4	2.3	1.7	0.5	0.1	0.0	0.0	0.0	29.2
40E1	0.0	0.1	1.6	1.2	1.8	0.6	0.1	0.0	0.0	0.0	0.0	5.5
40E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39E2	0.0	0.0	0.8	0.6	0.9	0.3	0.1	0.0	0.0	0.0	0.0	2.7
39E1	0.0	0.3	5.9	4.7	6.9	2.4	0.5	0.1	0.0	0.0	0.0	20.7
39E0	0.0	0.0	0.9	0.7	1.0	0.4	0.1	0.0	0.0	0.0	0.0	3.1
39D9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38E1	0.0	0.1	1.9	1.5	2.2	0.7	0.2	0.0	0.0	0.0	0.0	6.6
38E0	0.0	0.1	0.4	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	1.0
38D9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37E0	0.0	0.3	1.0	0.4	0.4	0.2	0.1	0.0	0.0	0.0	0.0	2.3
37D9	0.0	0.4	1.3	0.5	0.5	0.2	0.1	0.0	0.0	0.0	0.0	3.0
36D9	0.0	5.6	19.5	8.1	7.3	3.3	1.5	0.4	0.3	0.0	0.0	46.0
36D8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**0.0**	**1,115.4**	**214.7**	**166.3**	**380.0**	**352.1**	**125.0**	**18.9**	**9.7**	**4.7**	**0.0**	**2,386.8**
%	**0.0**	**46.7**	**9.0**	**7.0**	**15.9**	**14.8**	**5.2**	**0.8**	**0.4**	**0.2**	**0.0**	**100.0**
Cv (%)	**-**	**72.1**	**51.7**	**28.5**	**26.9**	**30.4**	**34.5**	**35.5**	**42.7**	**30.5**	**0.0**	**-**

VIaN	0.0	1,088.9	178.1	146.9	356.6	342.3	121.9	18.3	9.3	4.6	0.0	2,266.8
VIaS	0.0	20.4	14.9	10.3	15.3	6.1	1.4	0.2	0.1	0.1	0.0	68.7
VIIb	0.0	6.2	21.7	9.1	8.1	3.7	1.7	0.4	0.4	0.0	0.0	51.3

Table 7. Herring biomass (000's tonnes) at maturity by ICES statistical rectangle and division. Northwest herring survey, June\July 2014.

Strata	Immature	Mature	Spent	Total
45E4	0	0	0	0
45E3	0.7	0	0	0.7
45E2	0.6	1.1	1.6	3.4
45E1	0	0	0	0.1
44E4	0	0	0	0
44E3	15.5	0.7	0.1	16.3
44E2	0	0.1	0.1	0.2
44E1	0.7	26.1	38.6	65.5
44E0	0	0.7	1	1.8
43E3	0	0	0	0
43E2	0.1	0.9	1.3	2.2
43E1	0.4	20.7	30.4	51.4
43E0	0	0	0	0
42E3	0	0	0	0
42E2	0.1	1.4	2	3.5
42E1	0.8	13.4	19.4	33.7
42E0	0	0	0	0
41E3	66.1	0.5	0	66.6
41E2	0.4	4.4	6.6	11.4
41E1	0.6	8.1	12.2	20.9
41E0	0	0	0	0
40E3	1.6	0	0	1.6
40E2	1.6	0.4	0.6	2.7
40E1	0.2	0.3	0.3	0.8
40E0	0	0	0	0
39E2	0.1	0.1	0.2	0.4
39E1	0.8	1	1.3	3.1
39E0	0.1	0.1	0.2	0.5
39D9	0	0	0	0
38E1	0.3	0.3	0.4	1
38E0	0.1	0	0	0.1
38D9	0	0	0	0
37E1	0	0	0	0
37E0	0.1	0.1	0.1	0.3
37D9	0.2	0.1	0.1	0.4
36D9	2.9	1.3	1.7	5.9
36D8	0	0	0	0
Total	**94**	**81.8**	**118.4**	**294.2**
%	**32**	**27.8**	**40.2**	**100**

VIaN	87.5	78.1	113.4	279
VIaS	3.3	2.3	3	8.6
VIIb	3.2	1.4	1.9	6.6

Table 8. Herring abundance (millions) at maturity by ICES statistical rectangle and division. Northwest herring survey, June\July 2014.

Strata	Immature	Mature	Spent	Total
45E4	0.0	0.0	0.0	0.0
45E3	11.2	0.2	0.0	11.4
45E2	9.9	5.7	8.2	23.8
45E1	0.0	0.1	0.2	0.3
44E4	0.0	0.0	0.0	0.0
44E3	263.3	5.6	0.8	269.7
44E2	0.0	0.4	0.5	0.9
44E1	4.7	128.8	189.3	322.8
44E0	0.1	3.5	5.1	8.6
43E3	0.0	0.0	0.0	0.0
43E2	0.4	4.8	6.8	11.9
43E1	2.4	100.9	147.7	250.9
43E0	0.0	0.0	0.0	0.0
42E3	0.0	0.0	0.0	0.0
42E2	0.6	7.3	10.6	18.6
42E1	5.5	73.1	105.0	183.6
42E0	0.0	0.0	0.0	0.0
41E3	967.1	4.2	0.0	971.2
41E2	4.3	23.0	33.8	61.1
41E1	3.9	42.5	62.5	108.9
41E0	0.0	0.0	0.0	0.0
40E3	23.0	0.1	0.0	23.1
40E2	23.8	2.3	3.1	29.2
40E1	2.0	1.6	1.9	5.5
40E0	0.0	0.0	0.0	0.0
39E2	1.0	0.8	1.0	2.7
39E1	7.5	6.0	7.2	20.7
39E0	1.1	0.9	1.1	3.1
39D9	0.0	0.0	0.0	0.0
38E1	2.5	1.9	2.3	6.6
38E0	0.6	0.2	0.2	1.0
38D9	0.0	0.0	0.0	0.0
37E1	0.0	0.0	0.0	0.0
37E0	1.5	0.4	0.4	2.3
37D9	1.9	0.5	0.6	3.0
36D9	29.2	7.9	8.9	46.0
36D8	0.0	0.0	0.0	0.0
Total	**1,367.1**	**422.7**	**597.0**	**2,386.8**
%	**57.3**	**17.7**	**25.0**	**100**

VIaN	1,296.2	400.2	570.4	2,266.8
VIaS	38.3	13.7	16.7	68.7
VIIb	32.5	8.8	9.9	51.3

Table 9. Herring biomass and abundance by ICES statistical rectangle. Northwest herring survey, June\July 2014.

Stratum	No. Transects	No. Schools	Def Schools	Mix Schools	Prob. Schools	% zeros	Def. Bio.	Mix Bio.	Prob. Bio.	Biomass ('000's t)	SSB ('000's t)	Abund (mills.)
45E4	3	0	0	0	0	100	0	0	0	0	0	0.0
45E3	5	14	0	0	14	80	0	0	0.7	0.7	0	11.4
45E2	2	30	0	0	30	0	0	0	3.4	3.4	2.8	23.8
45E1	2	1	0	0	1	50	0	0	0.1	0.1	0.1	0.3
44E4	2	0	0	0	0	100	0	0	0	0	0	0.0
44E3	6	6	0	0	6	67	0	0	16.3	16.3	0.8	269.7
44E2	2	3	0	0	3	0	0	0	0.2	0.2	0.2	0.9
44E1	2	21	19	0	2	0	65.1	0	0.4	65.5	64.7	322.8
44E0	2	3	0	0	3	50	0	0	1.8	1.8	1.8	8.6
43E3	5	0	0	0	0	100	0	0	0	0	0	0.0
43E2	6	1	0	0	1	83	0	0	2.2	2.2	2.1	11.9
43E1	2	5	5	0	0	50	51.4	0	0	51.4	51	250.9
43E0	2	0	0	0	0	100	0	0	0	0	0	0.0
42E3	2	0	0	0	0	100	0	0	0	0	0	0.0
42E2	6	6	0	0	6	50	0	0	3.5	3.5	3.4	18.6
42E1	4	61	31	0	30	0	30.3	0	3.4	33.7	32.9	183.6
42E0	2	0	0	0	0	100	0	0	0	0	0	0.0
41E3	3	14	0	0	14	33	0	0	66.6	66.6	0.5	971.2
41E2	4	32	0	0	32	25	0	0	11.4	11.4	11	61.1
41E1	4	54	10	0	44	0	9.7	0	11.2	20.9	20.3	108.9
41E0	4	0	0	0	0	100	0	0	0	0	0	0.0
40E3	4	15	0	0	15	75	0	0	1.6	1.6	0	23.1
40E2	4	26	0	0	26	25	0	0	2.7	2.7	1	29.2
40E1	4	11	0	0	11	25	0	0	0.8	0.8	0.6	5.5
40E0	4	0	0	0	0	100	0	0	0	0	0	0.0
39E2	2	4	1	0	3	0	0	0	0.4	0.4	0.3	2.7
39E1	4	28	7	0	21	0	0.5	0	2.6	3.1	2.3	20.7
39E0	4	15	0	0	15	25	0	0	0.5	0.5	0.3	3.1
39D9	1	0	0	0	0	100	0	0	0	0	0	0.0
38E1	4	5	0	1	4	25	0	0	0.9	1	0.7	6.6
38E0	4	1	0	1	0	75	0	0.1	0	0.1	0.1	1.0
38D9	4	0	0	0	0	100	0	0	0	0	0	0.0
37E1	1	0	0	0	0	100	0	0	0	0	0	0.0
37E0	2	3	0	3	0	0	0	0.3	0	0.3	0.1	2.3
37D9	4	1	0	1	0	75	0	0.4	0	0.4	0.2	3.0
36D9	3	8	0	8	0	67	0	5.9	0	5.9	3	46.0
36D8	2	0	0	0	0	100	0	0	0	0	0	0.0
Total	**121**	**368**	**73**	**14**	**281**	**56**	**157**	**6.7**	**130.7**	**294.5**	**200.2**	**2,386.8**
Cv (%)	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**28.6**	**-**	**38.8**

Table 10. Historic survey time-series for areas VIaS and VIIb. Abundance (millions), TSB and SSB (tonnes), age in winter rings. Northwest herring survey, June\July 2014.

Winter rings	2008	2009	2010	2011	2012	2013	2014
0	-	-	-	-	-	-	-
1	6.1	416.4	16.5	44.6	25.9	-	26.6
2	75.9	81.3	292.8	86.3	360.9	49.7	36.6
3	64.7	11.4	85.2	146.8	92.8	103.5	19.3
4	38.4	15.1	63.2	28.9	42.9	108.1	23.4
5	22.3	7.7	43.2	5.7	8.0	26.9	9.8
6	26.2	7.1	27.3	4.3	3.7	6.8	3.1
7	9.1	7.5	19.0	4.8	3.5	4.1	0.6
8	5.0	0.4	12.5	2.1	2.1	1.8	0.4
9	3.7	0.9	5.5	1.4	1.3	0.7	0.1
10+	-	-	-	0.8	1.1	0.2	-
TSN (mil)	251.4	547.7	565.2	325.7	542.2	301.7	120.0
TSB (t)	44,611	46,460	82,100	40,700	68,300	45,500	15,100
SSB (t)	43,006	20,906	81,400	28,600	42,600	34,300	8,600
CV	34.2	32.2	-	-	-	-	-

Survey coverage: VIaS & VIIb

Table 11. Historic survey time-series for all areas surveyed. Abundance (millions), TSB and SSB (tonnes), age in winter rings. Northwest herring survey, June\July 2014. Note that the 2011-2014 survey coverage in VIaN was much greater than that in 2010.

Winter rings	2008^	2009^	2010*	2011*	2012*	2013*	2014*
0	-	-	-	-	-	-	-
1	6.1	416.4	524.8	82.1	608.3	-	1115.4
2	75.9	81.3	504.3	202.5	451.5	96.2	214.7
3	64.7	11.4	133.3	752.0	444.6	254.3	166.3
4	38.4	15.1	107.4	381.0	516.1	265.8	380.0
5	22.3	7.7	103.0	110.8	180.3	78.7	352.1
6	26.2	7.1	83.7	124.0	115.4	26.9	125.0
7	9.1	7.5	57.6	118.4	116.9	18.5	18.9
8	5.0	0.4	35.3	70.7	83.8	10.8	9.7
9	3.7	0.9	17.5	41.6	56.3	4.1	4.7
10+	-	-	-	25.6	42.0	1.2	0.0
TSN (mil)	251.4	547.7	1,566.9	1,908.7	2,615.0	756.6	2,386.8
TSB (t)	44,611	46,460	192,979	313,305	397,797	118,946	294,200
SSB (t)	43,006	20,906	170,154	284,632	325,835	92,700	200,200
CV	34.2	32.2	24.7	22.4	22.8	21.5	28.6

^ Survey coverage: VIaS & VIIb

* Survey coverage: VIaS, VIaN & VIIb

Table 12. Sprat biomass and abundance by ICES statistical rectangle. Northwest herring survey, June\July 2014.

Stratum	No. Transects	No. Schools	Def Schools	Mix Schools	Prob. Schools	% zeros	Def. Bio.	Mix Bio.	Prob. Bio.	Biomass ('000's t)	SSB ('000's t)	Abund (mills.)
41E3	3	28	17	0	11	33	1.9	0	1.3	3.2	0	266.3
41E2	4	13	0	0	13	75	0	0	0.1	0.1	0	6.8
40E3	4	17	0	0	17	25	0	0	6.3	6.3	0	519.2
40E2	4	7	0	0	7	75	0	0	0.4	0.4	0	32.5
39E2	2	2	0	0	2	50	0	0	0.1	0.1	0	5.3
Total	**121**	**67**	**17**	**0**	**50**	**93**	**1.9**	**0**	**8.2**	**10.1**	**0**	**830.1**

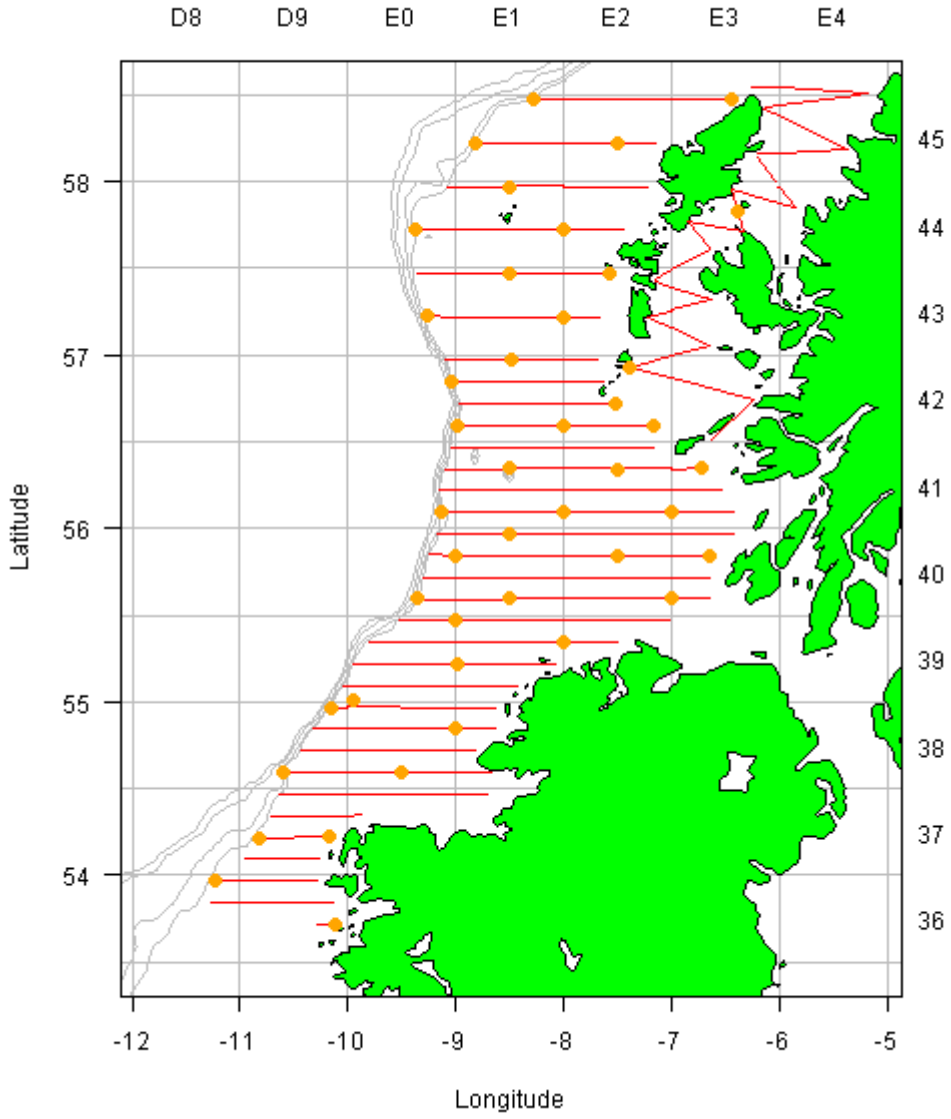


Figure 1. RV Celtic Explorer cruise track during the Northwest herring survey, June\July 2014 (excluding inter-transect segments). Orange circles are hydrographic stations.

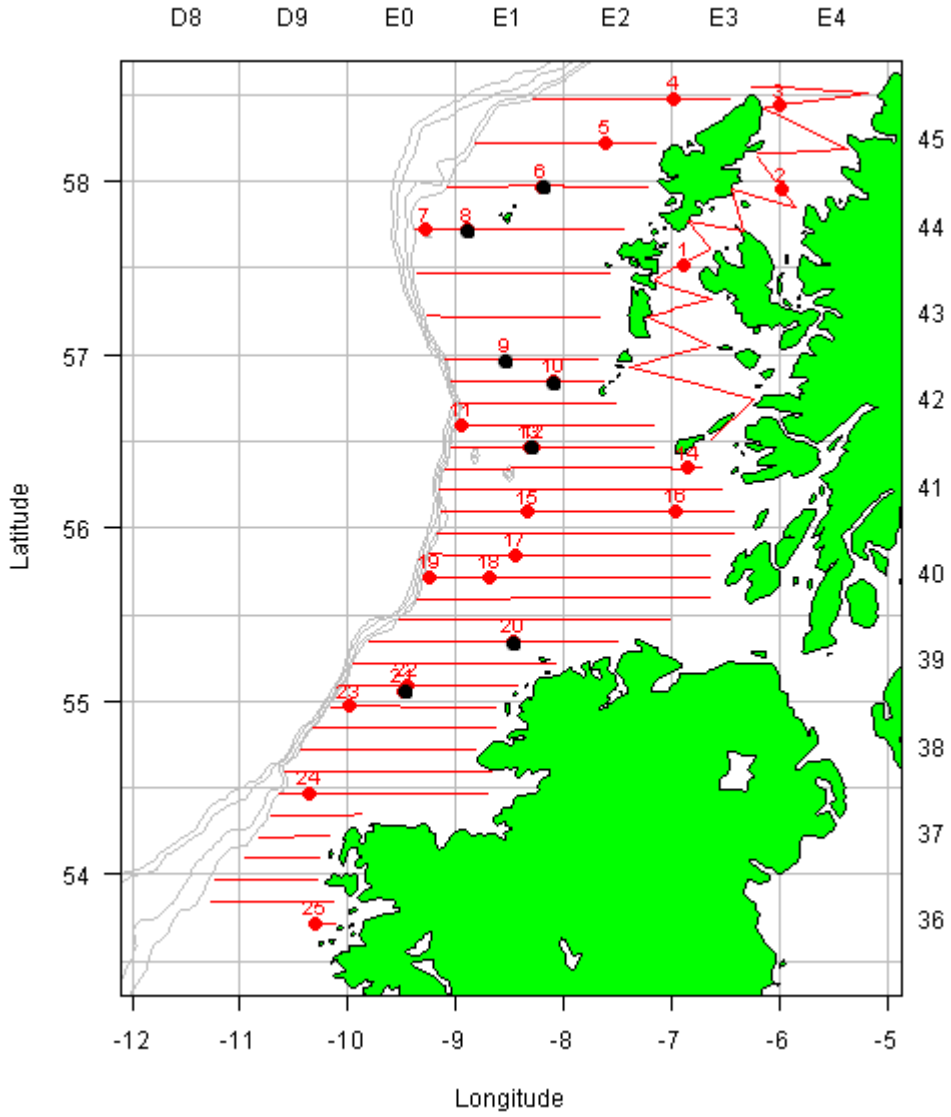


Figure 2. RV Celtic Explorer fishing trawl stations. Northwest herring survey, June\July 2014. SGHERWAY sampled hauls are indicated in black.

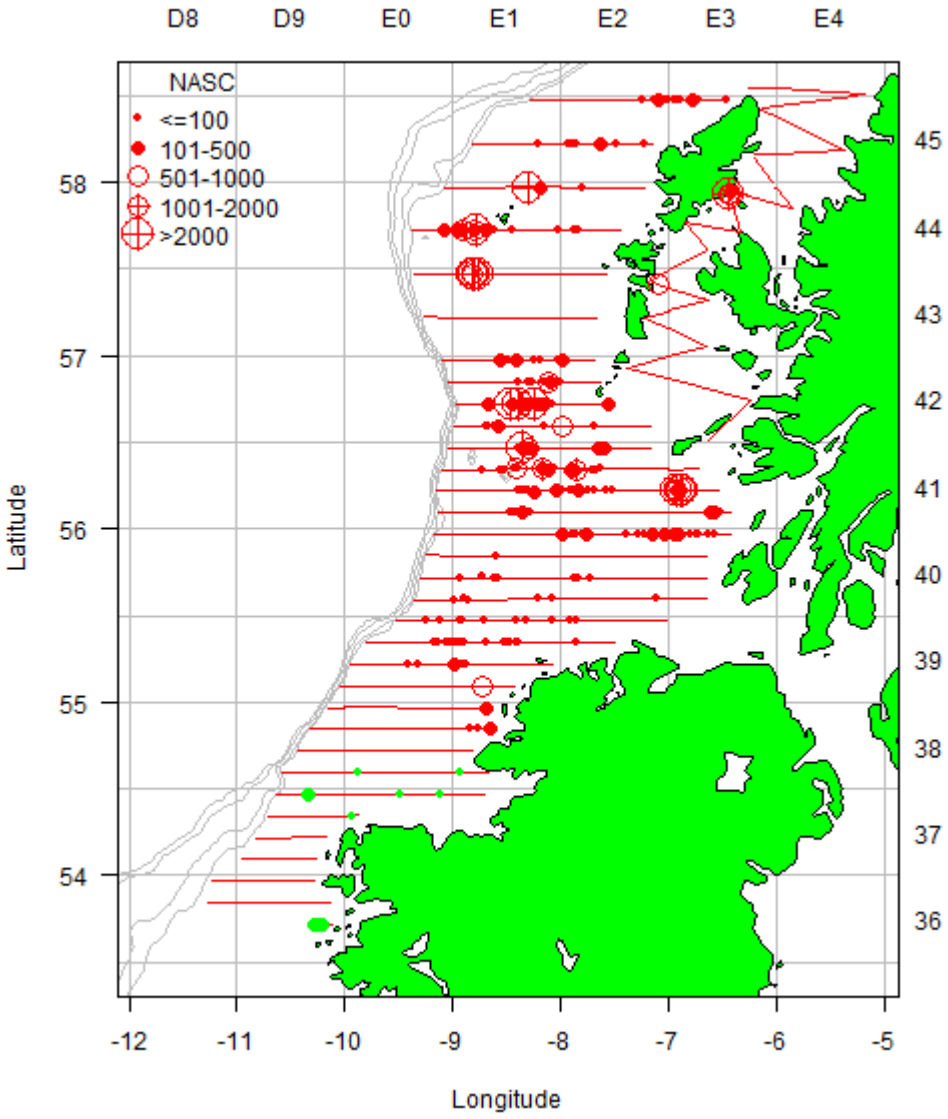


Figure 3. NASC plot of herring distribution during the 2014 survey. Red circles represent single herring schools ("definitely" and "probably" herring categories). Green circles represent herring occurring in mixed schools.

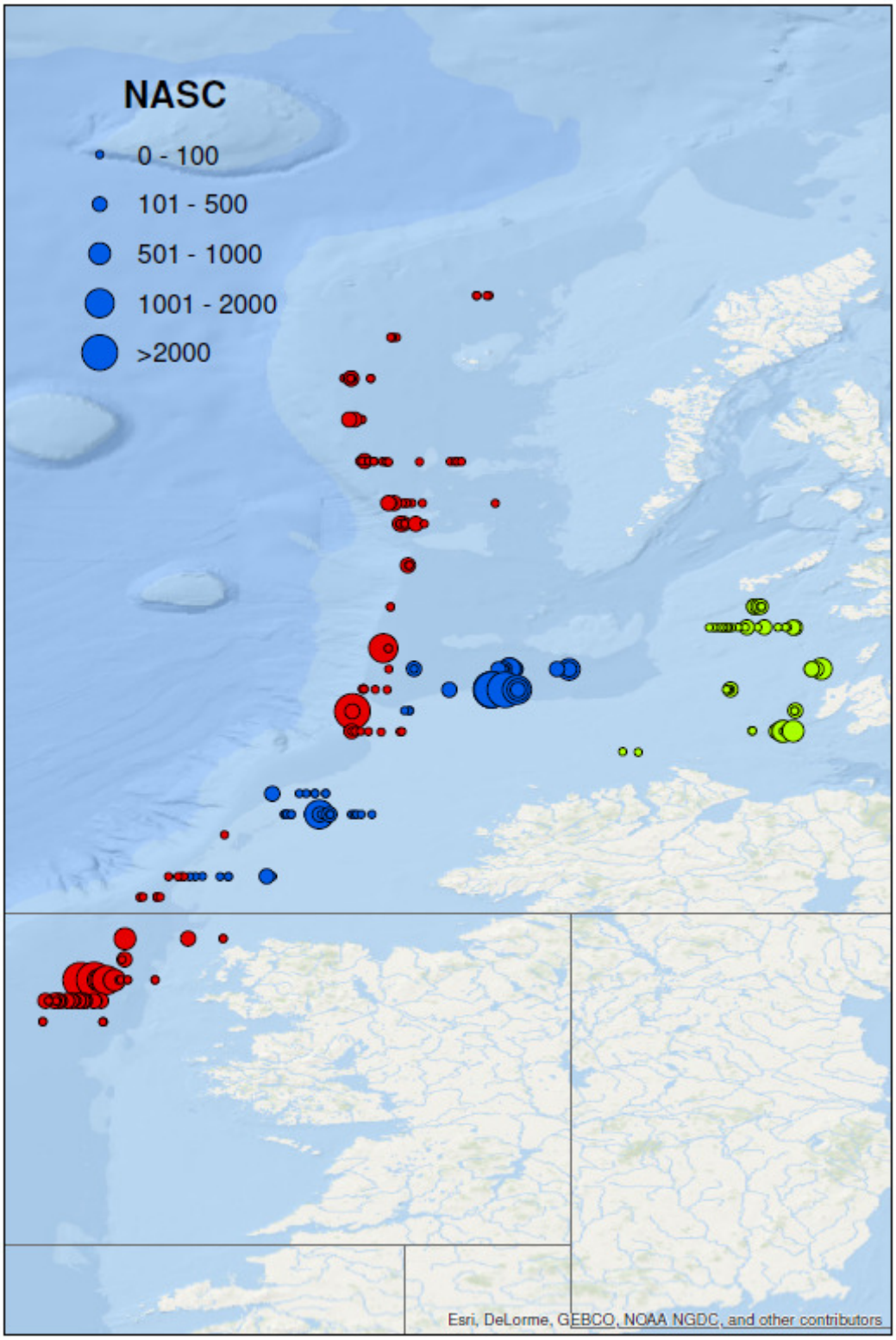


Figure 4. NASC plot of boarfish (red, *Capros aper*), blue whiting (blue, *Micromesistius poutassou*) and sprat (green, *Sprattus sprattus*) distribution during the 2014 Northwest herring survey.

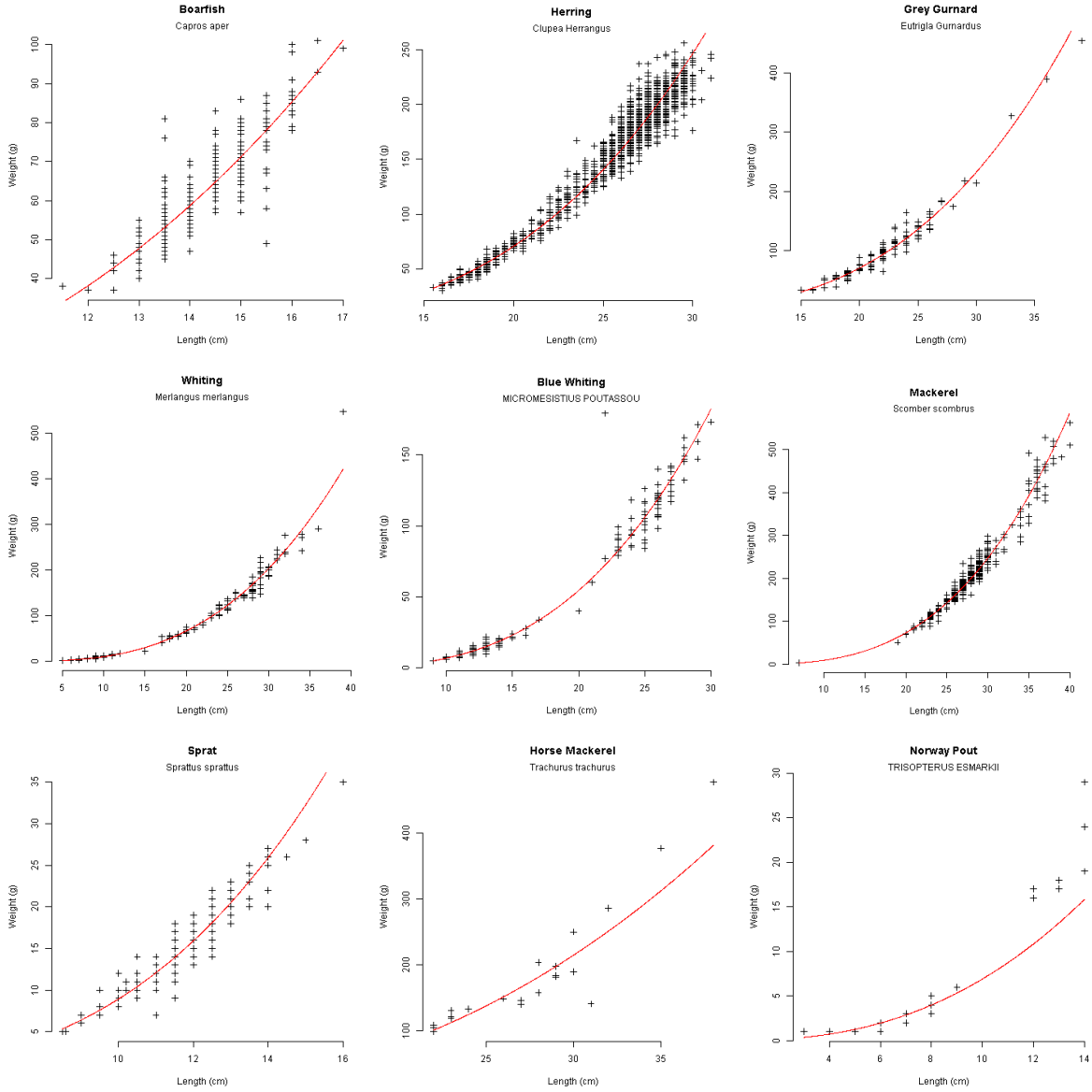


Figure 5. Length-weight plots of major species encountered during the Northwest herring acoustic survey, June\July 2014.

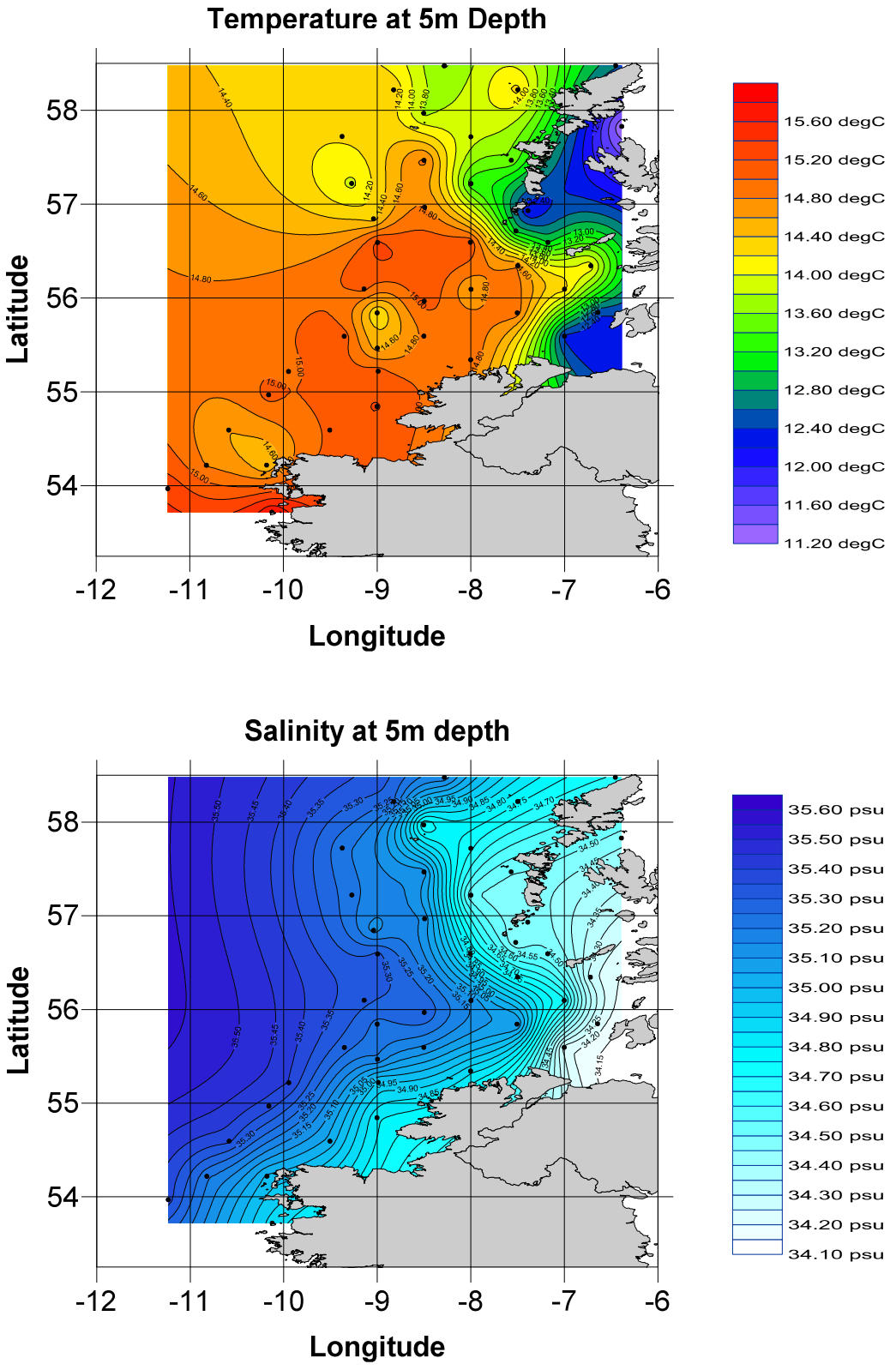


Figure 6. Horizontal temperature (top panel) and salinity (bottom panel) at 5m subsurface as derived from vertical CTD cast data (black squares). Northwest herring survey, June/July 2014.

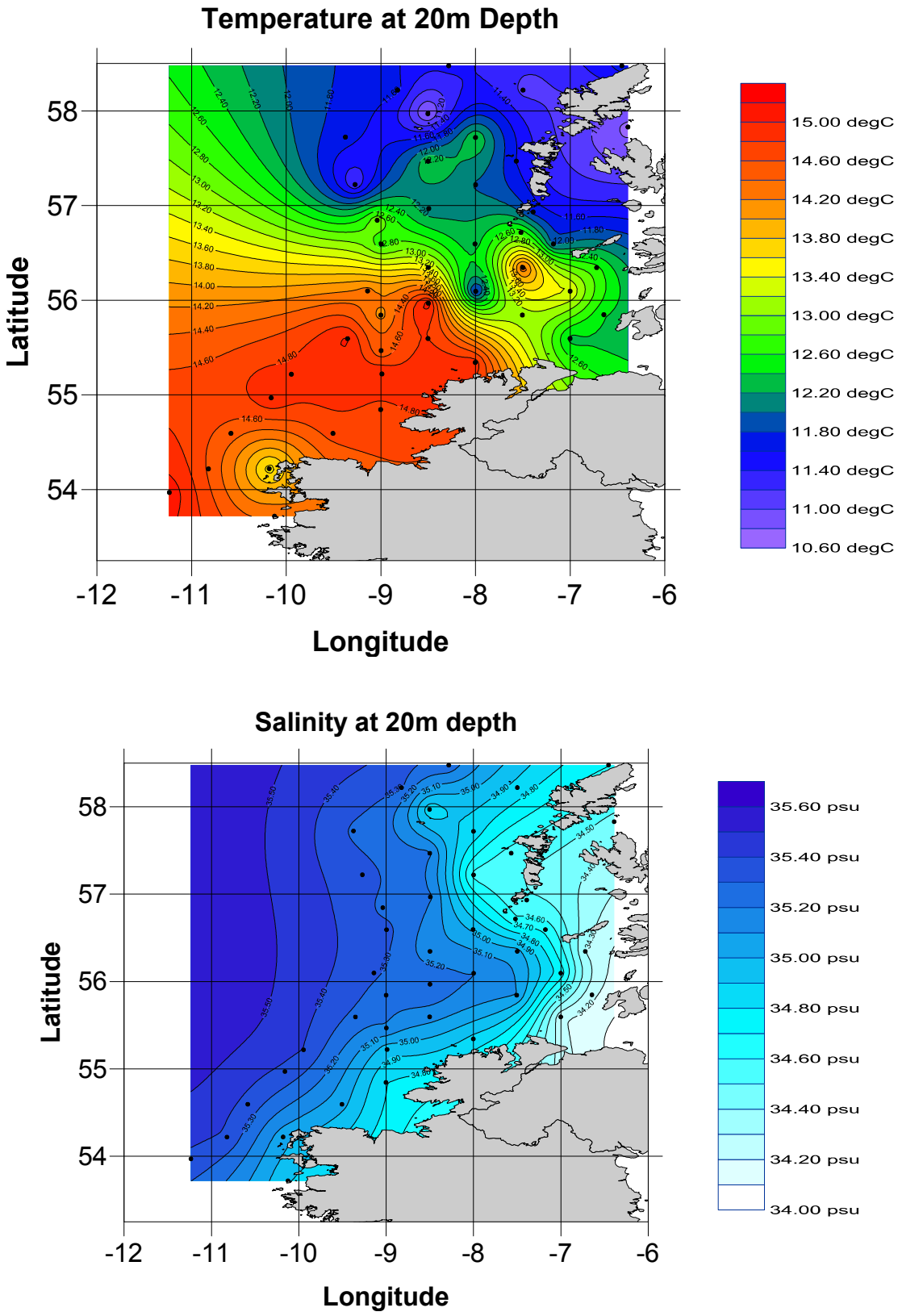


Figure 7. Horizontal temperature (top panel) and salinity (bottom panel) at 20m subsurface as derived from vertical CTD cast data (black squares). Northwest herring survey, June/July 2014.

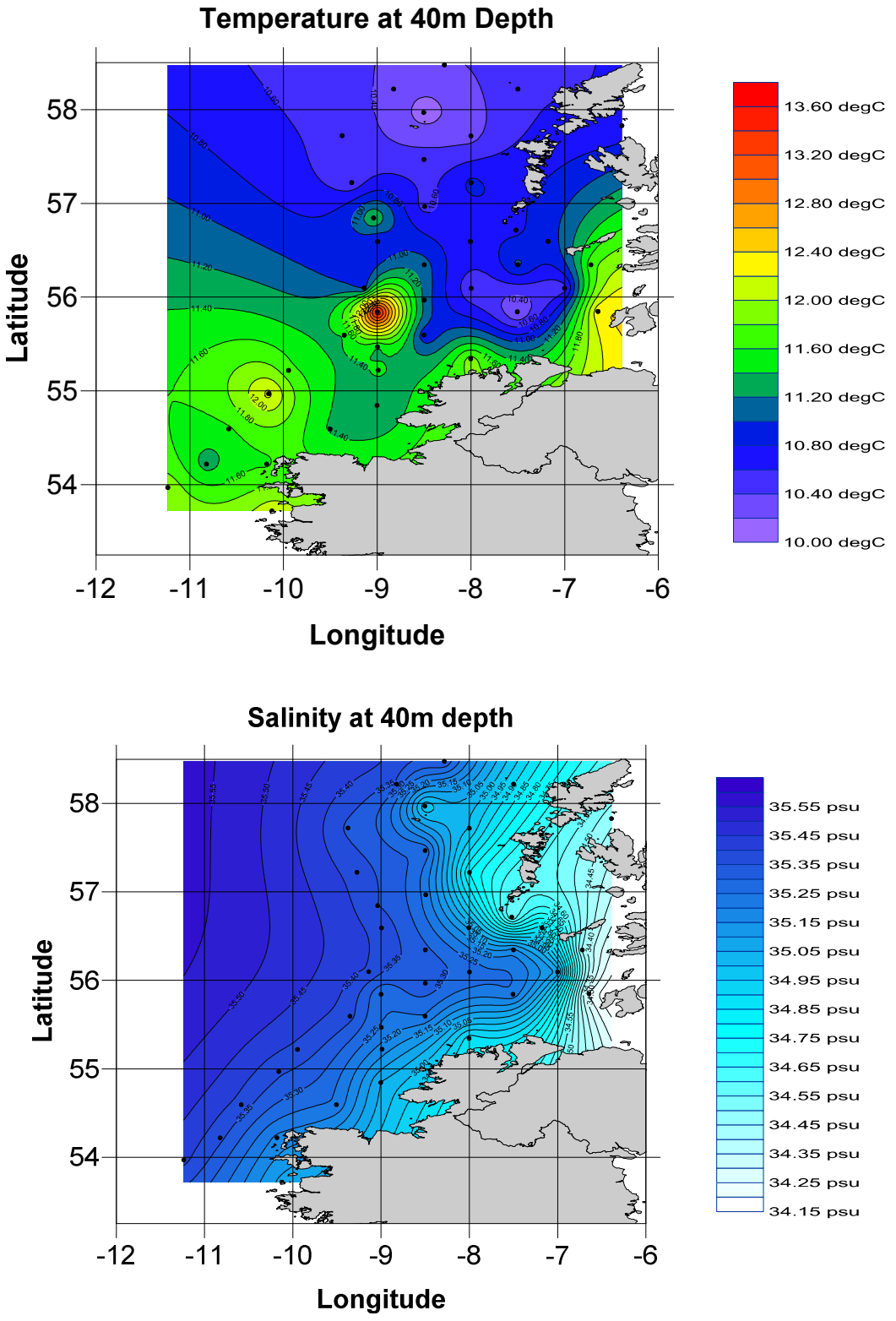


Figure 8. Horizontal temperature (top panel) and salinity (bottom panel) at 40m subsurface as derived from vertical CTD cast data (black squares). Northwest herring survey, June/July 2014.

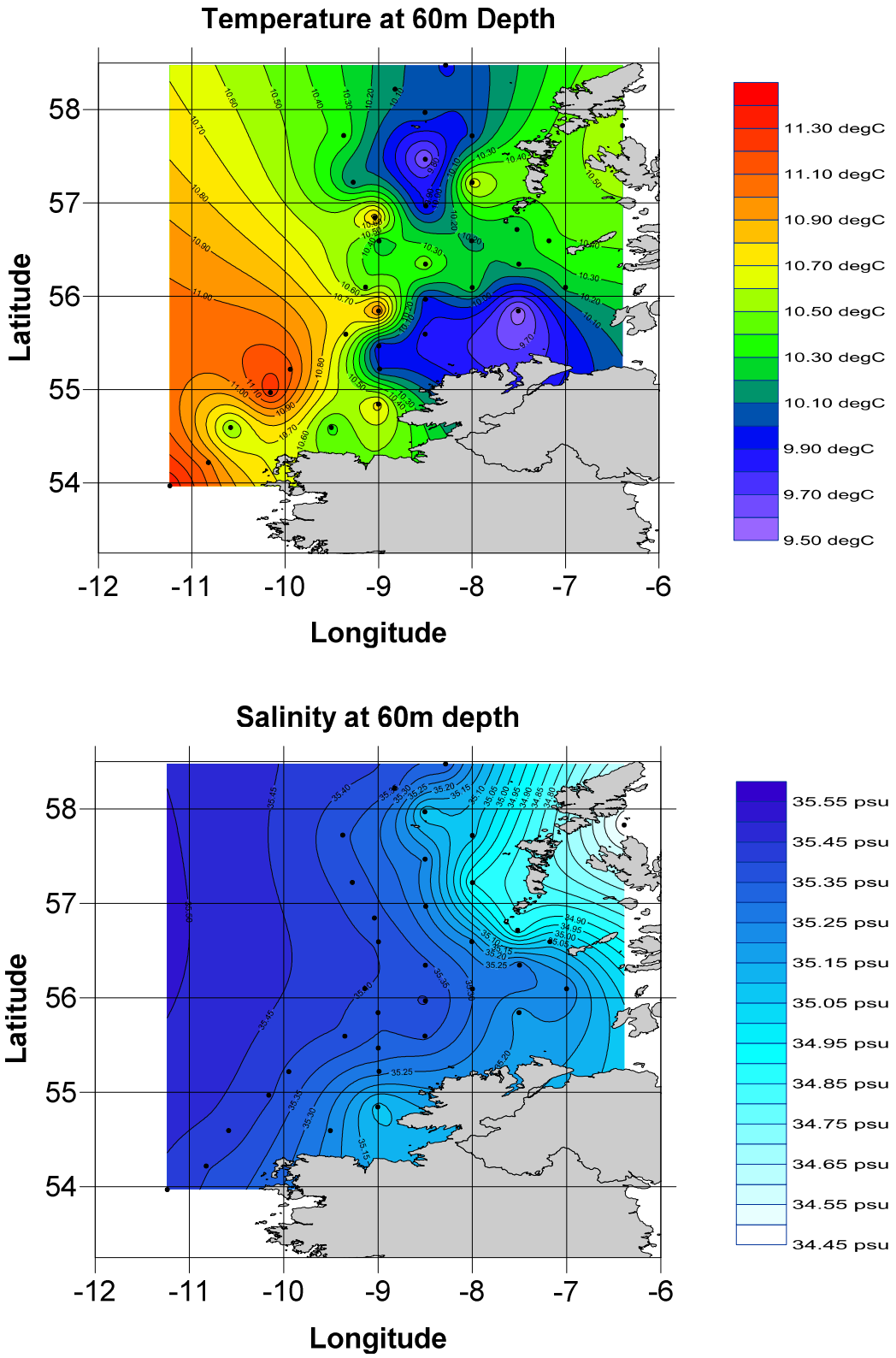


Figure 9. Horizontal temperature (top panel) and salinity (bottom panel) at 60m subsurface as derived from vertical CTD cast data (black squares). Northwest herring survey, June/July 2014.

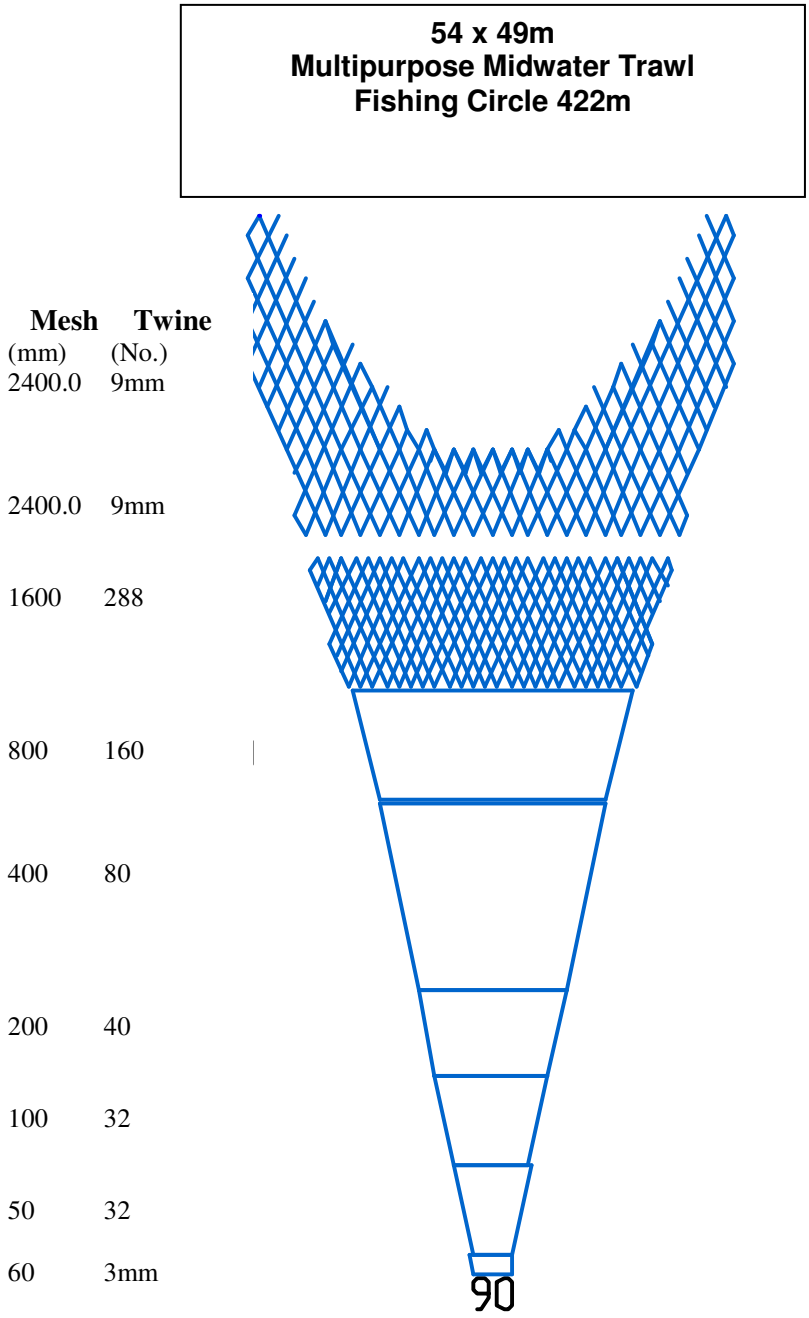
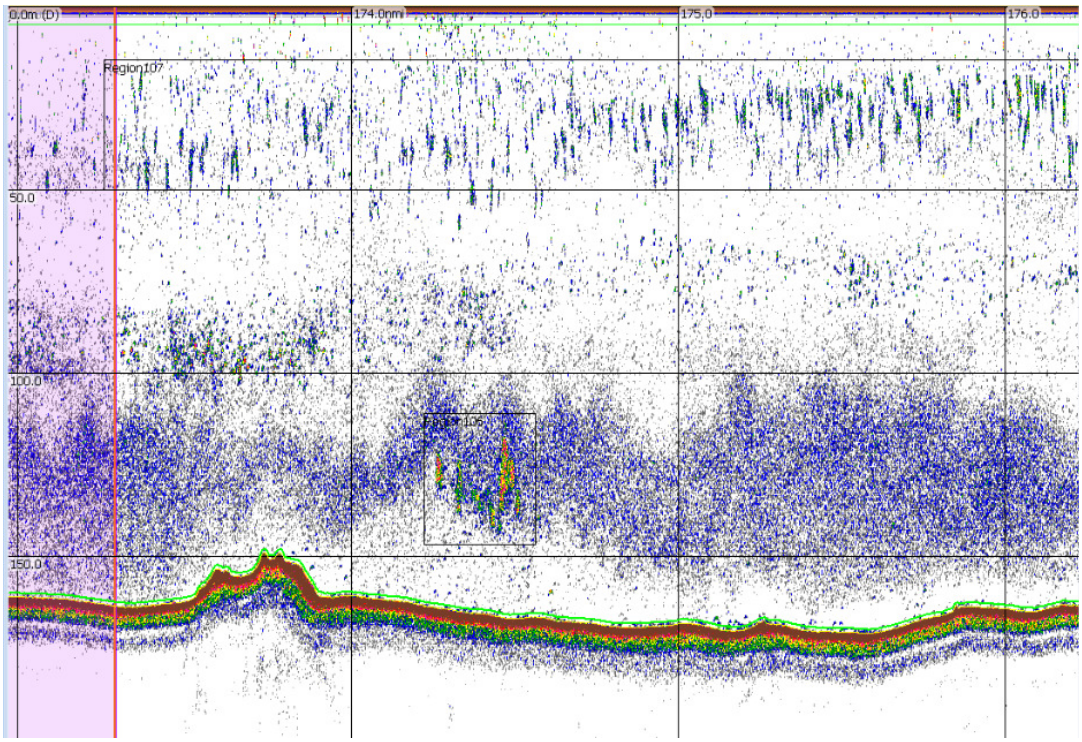
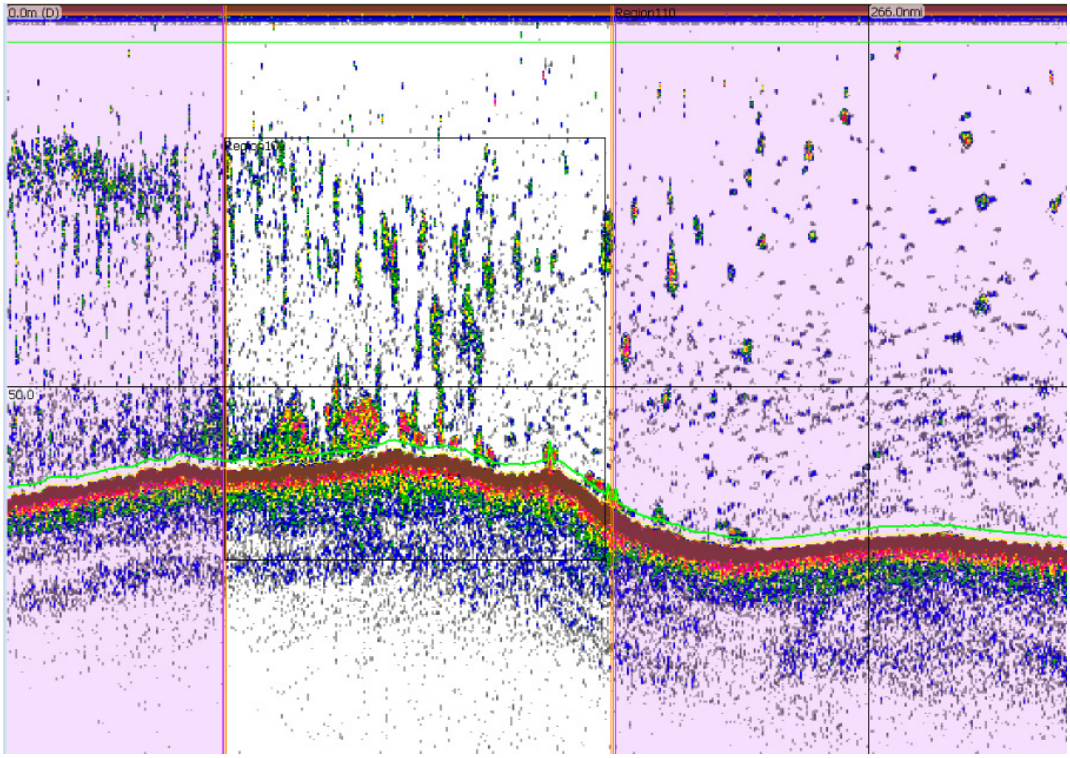


Figure 10. Celtic Explorer multi-purpose midwater trawl employed during the Northwest herring acoustic survey, June\July 2014.

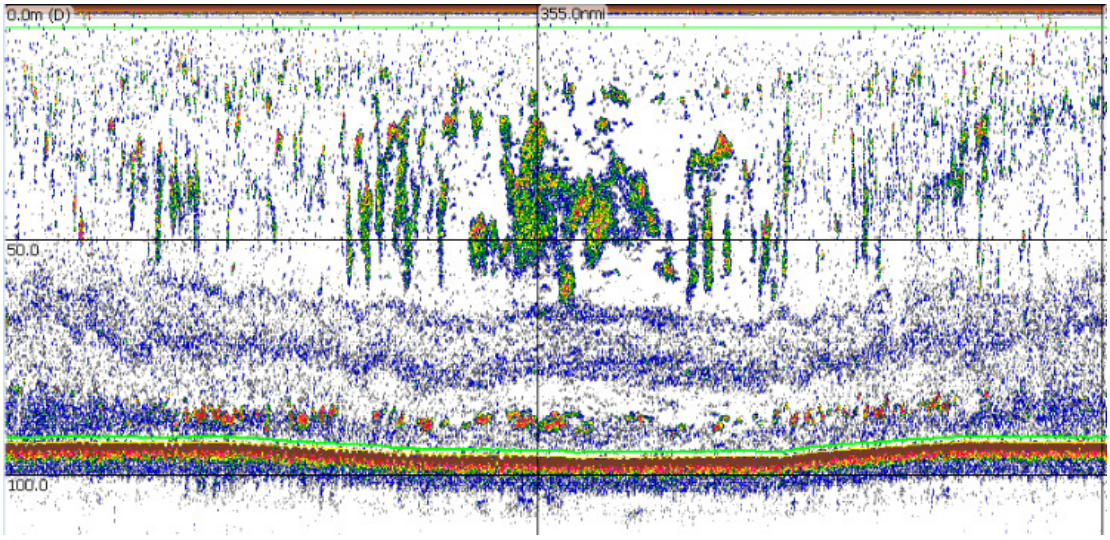
Appendix 1: Echograms prior to fishing



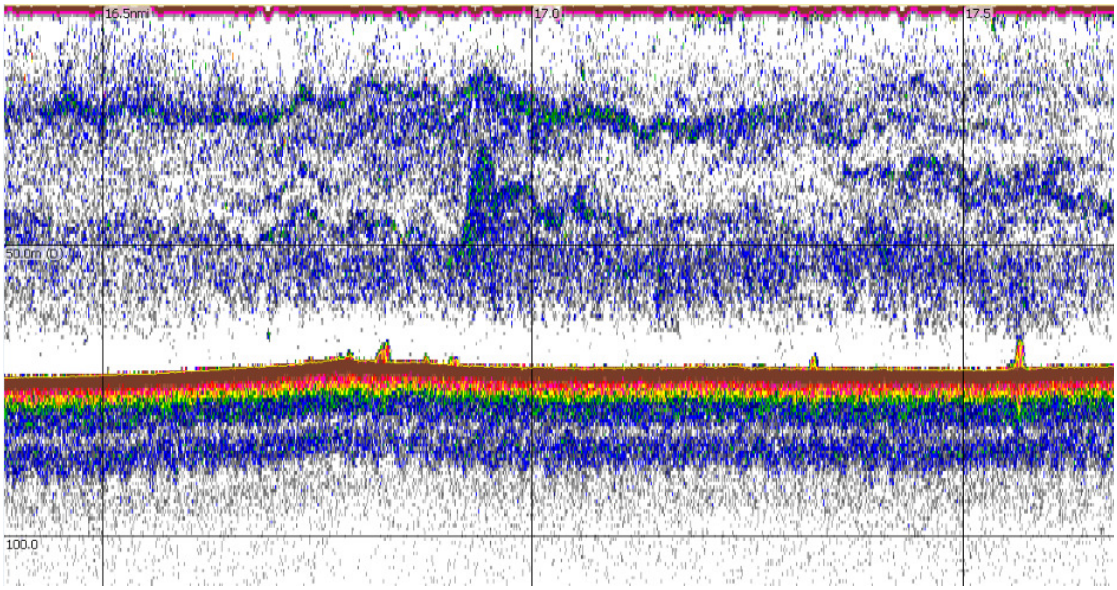
Haul 1. 25/6/14. A scattered, mid-water mark in the Minch. The original mark was not seen again once the net was in the water. Two small bottom marks close by yielded 60 kg of mixed species. Vertical lines represent 1 nmi, horizontal lines represent 50m depth.



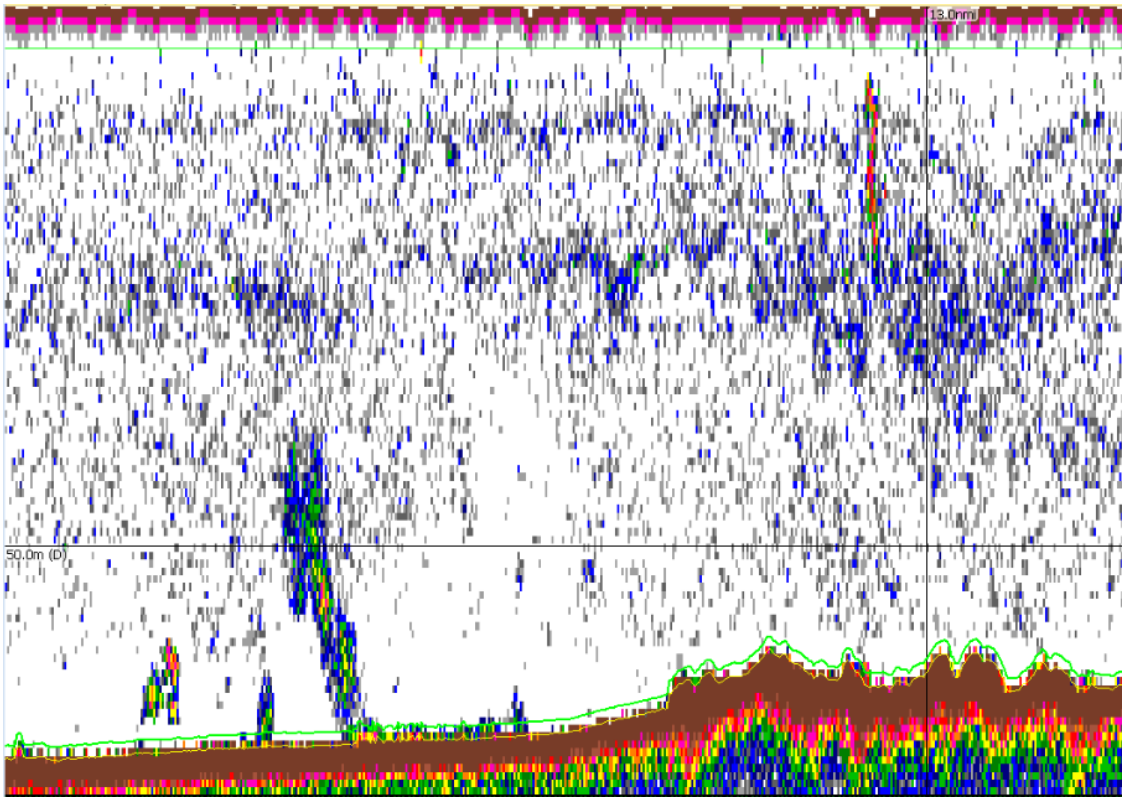
Haul 2. 25/6/14. Mid-water and bottom marks in the Minch. Mainly comprised of jellyfish but 10kg of herring were also present.



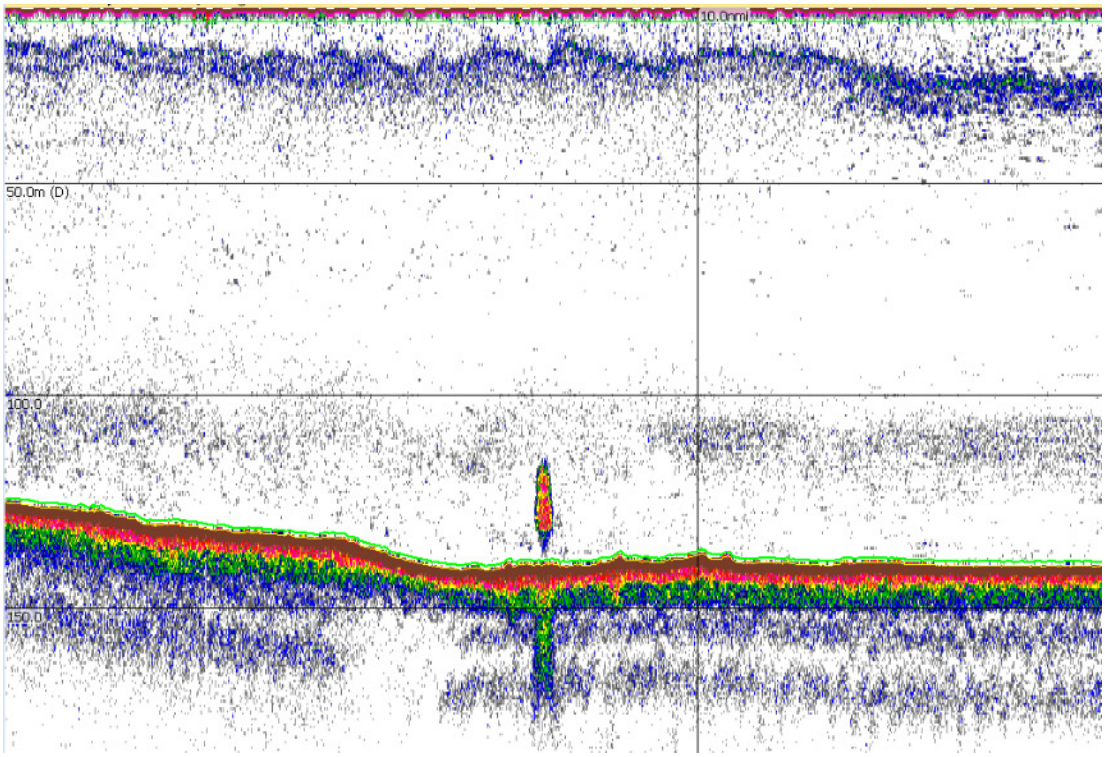
Haul 3. 26/6/14. A number of mid-water and bottom marks in the north Minch. The lower marks were targeted and yielded a mixture of demersal species in addition to a handful of herring.



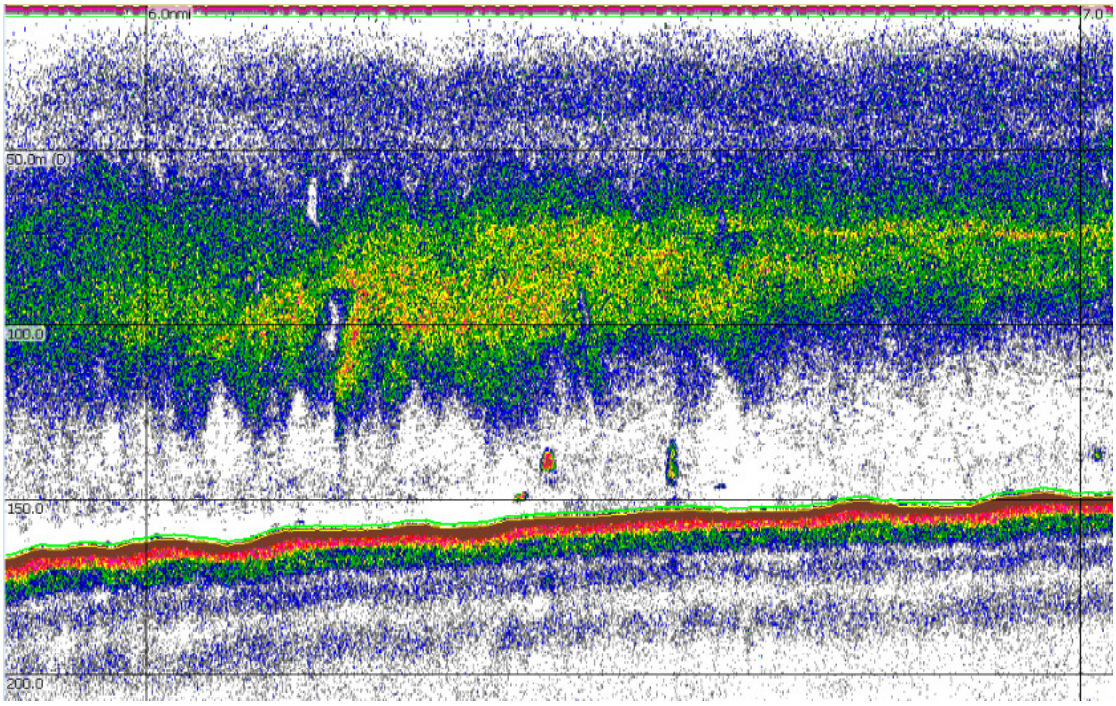
Haul 4. 26/6/14. These three small bottom marks on the first transect west of the Hebrides were not seen on the headline transducer after the gear was deployed. Fishing close to the bottom yielded a mixture of demersal species.



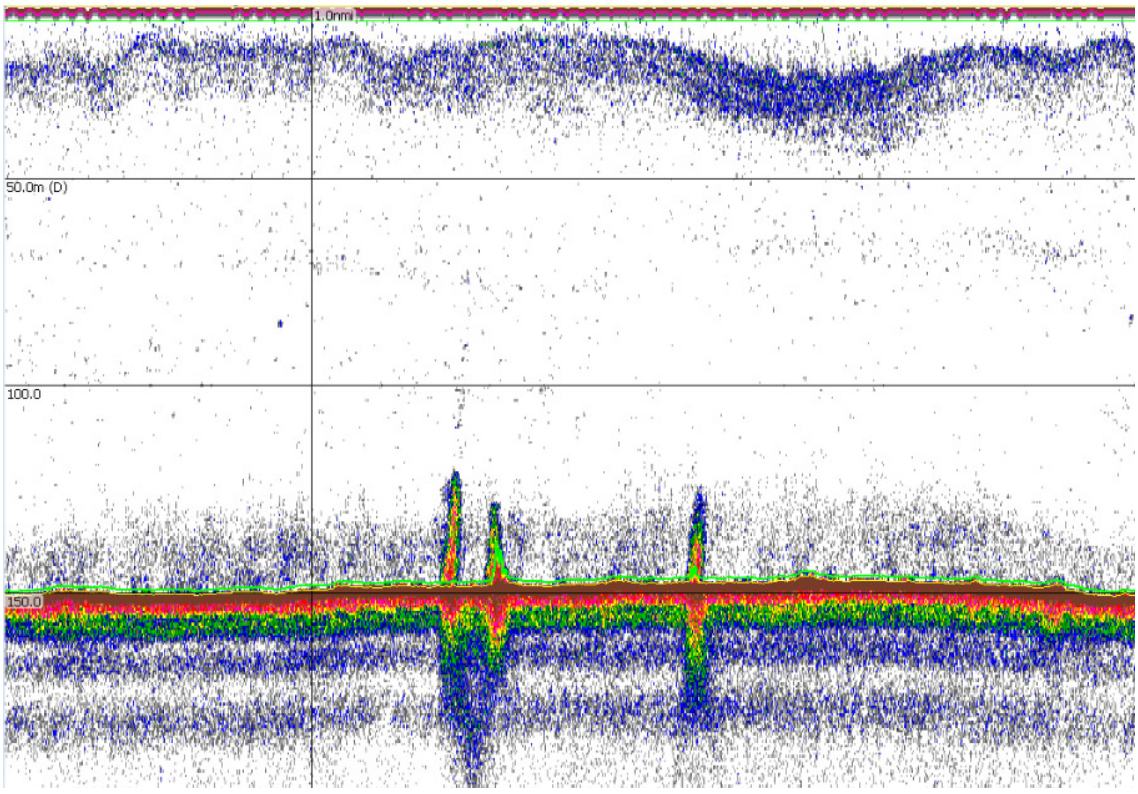
Haul 5. 27/6/14. This tall diffuse mark over rough ground was not captured.



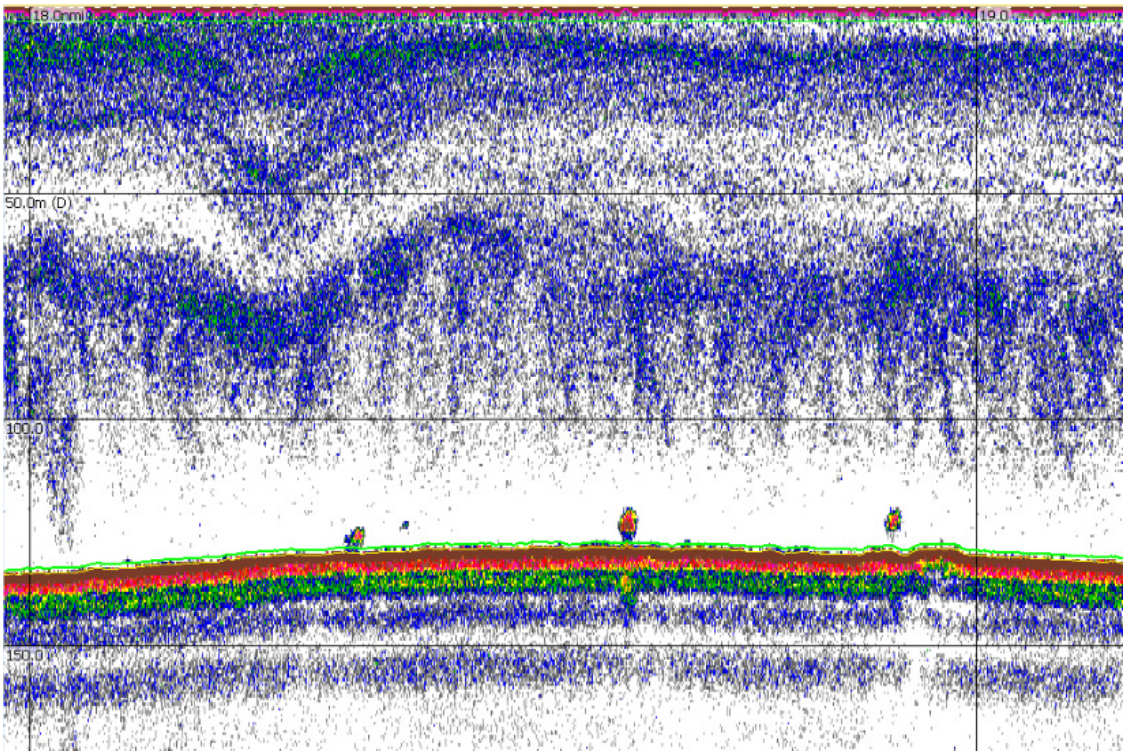
Haul 6. 27/6/14. This pillar of herring (4000 kg) was sampled north east of St. Kilda.



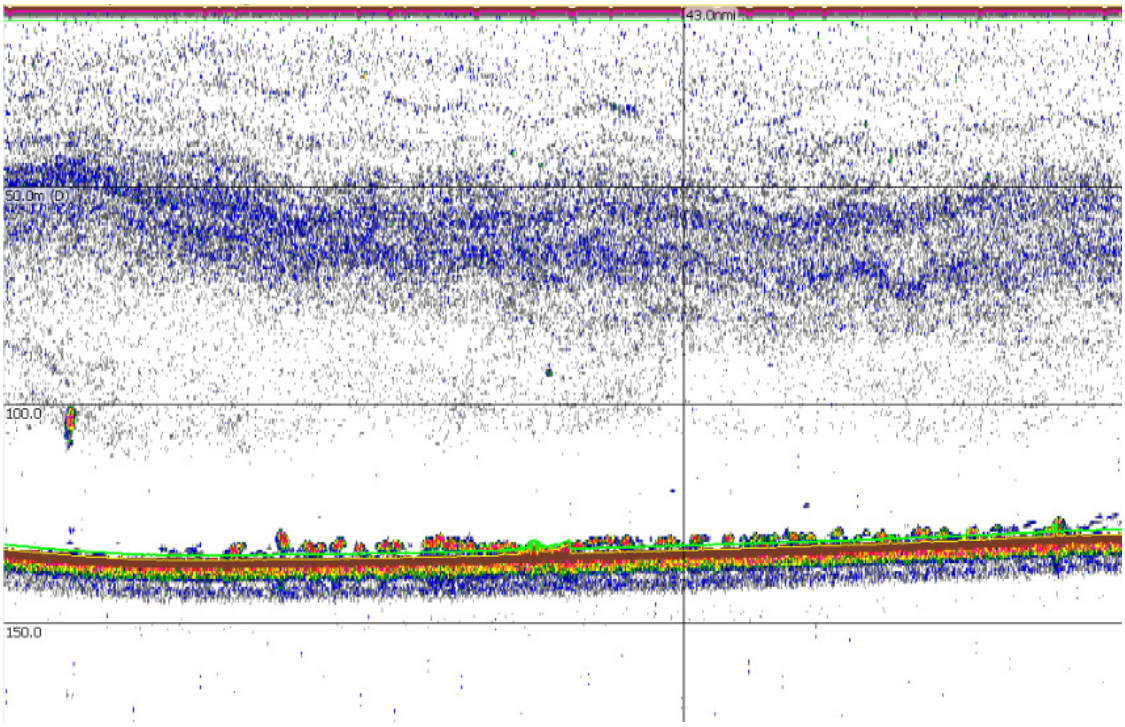
Haul 7. 28/6/14. Two small schools of boarfish on the shelf edge in stat rectangle 44E0.



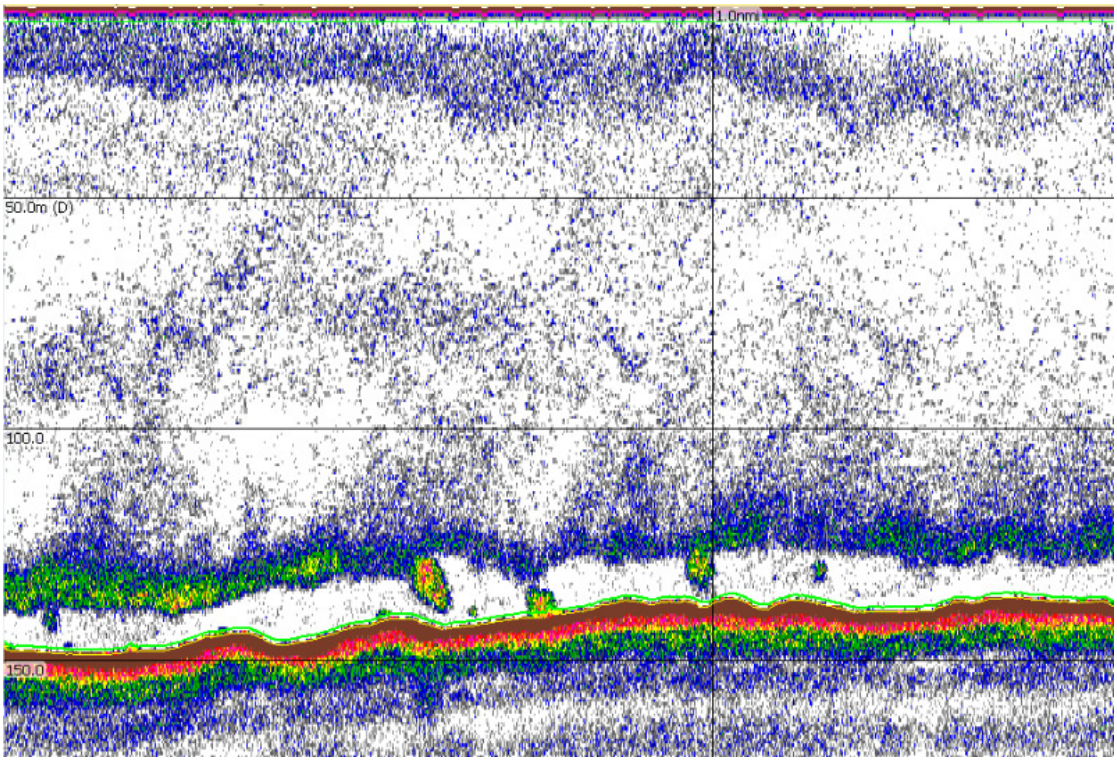
Haul 8. 28/6/14. Three typical herring marks in 150m of water west of St. Kilda. The sampled was composed almost purely of herring.



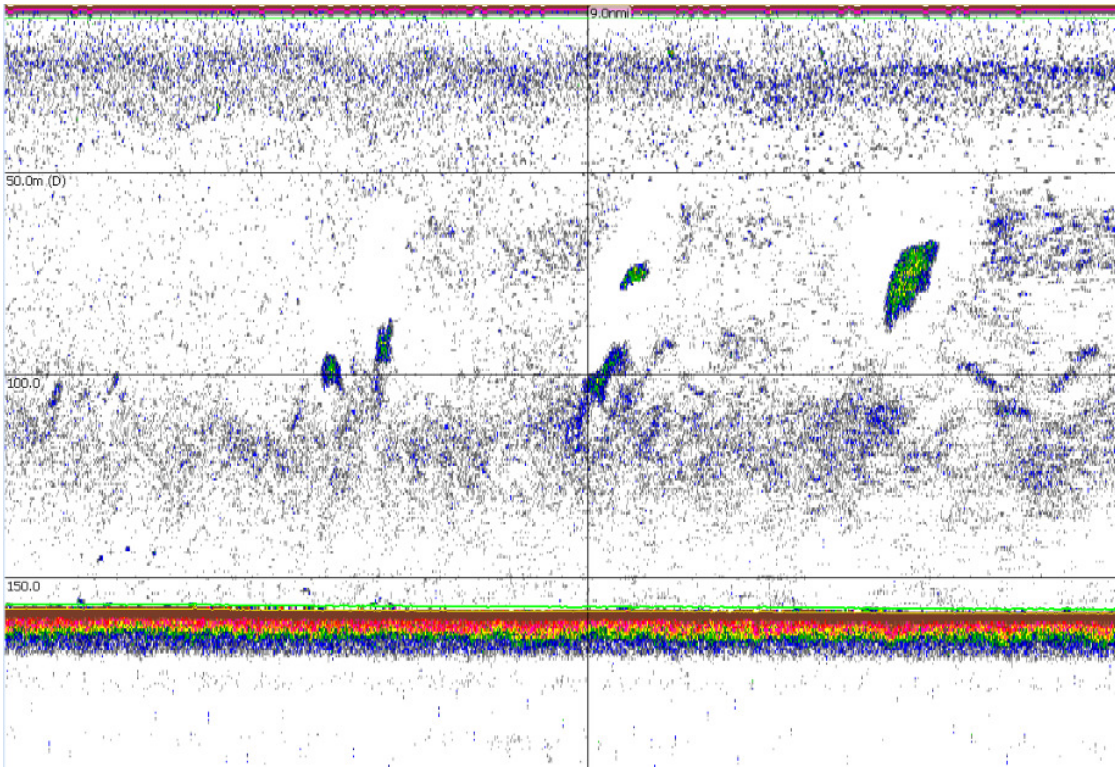
Haul 9. 29/6/14. Three balls of herring in stat rectangle 42E1. One of the marks was captured and contained 750kg of herring.



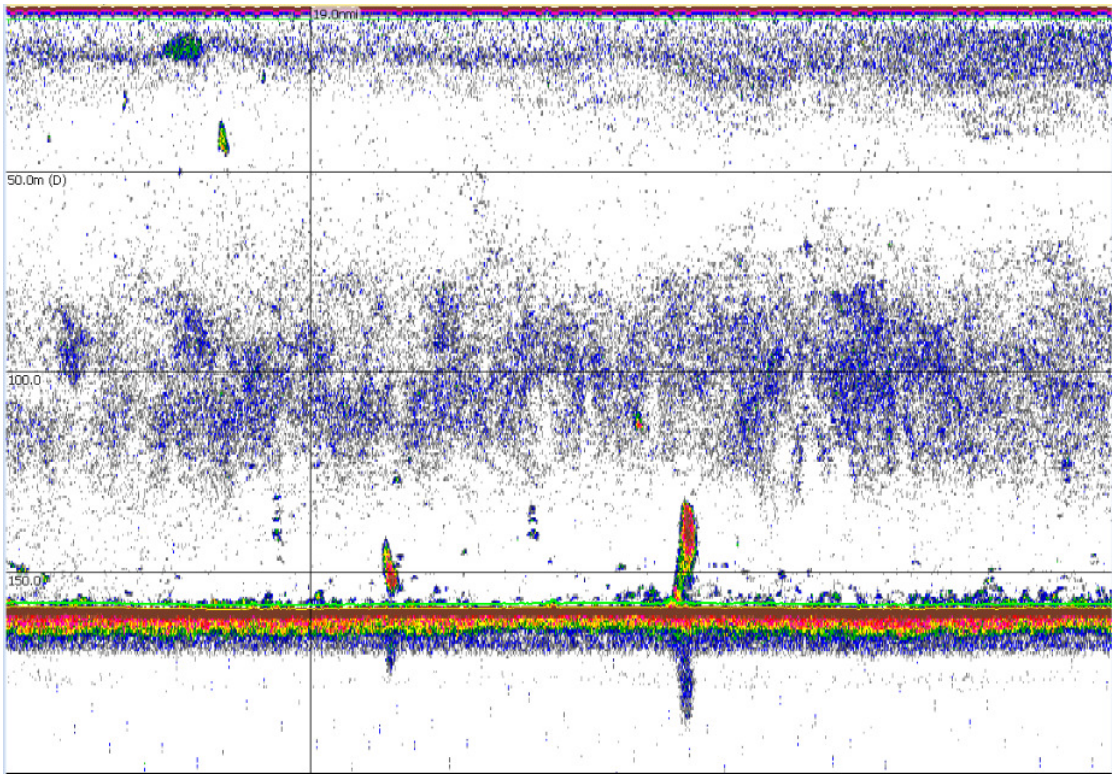
Haul 10. 30/6/14. This scattered bottom layer, observed early in the morning west of Mingulay, was entirely herring (750 kg).



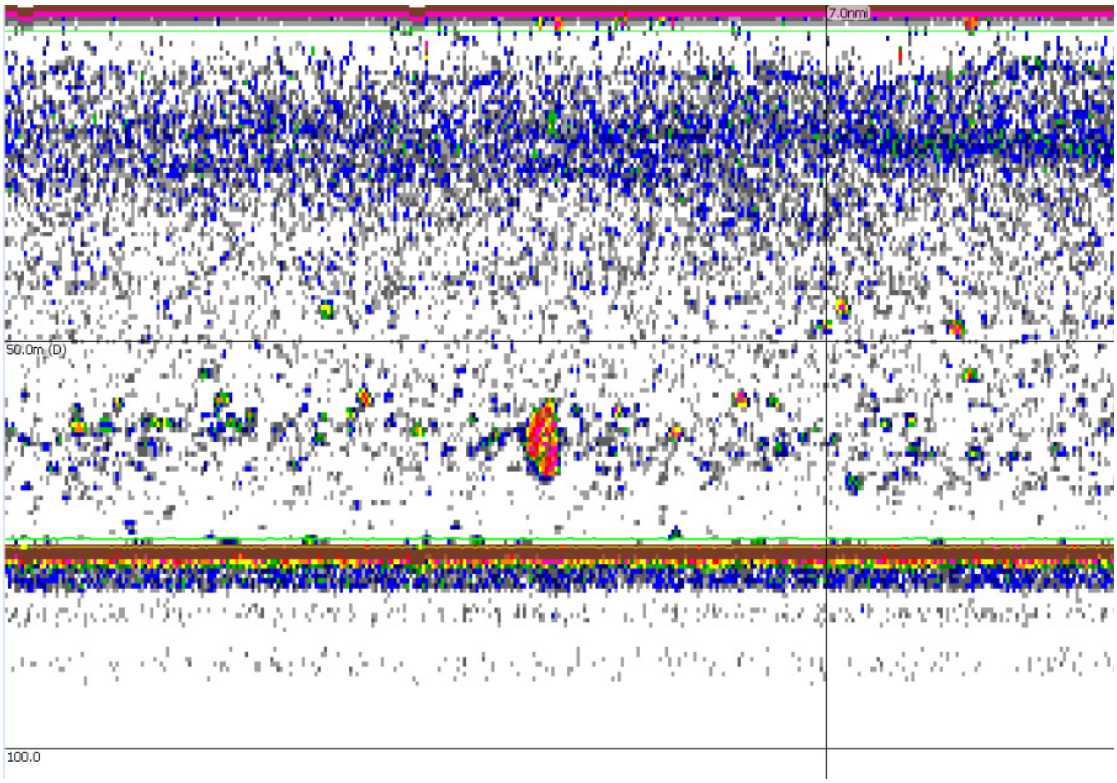
Haul 11. 30/6/14. A number of marks on the shelf edge near 56.5° N. One mark, seen entering the net mouth on the headline transducer, yielded 500kg of boarfish.



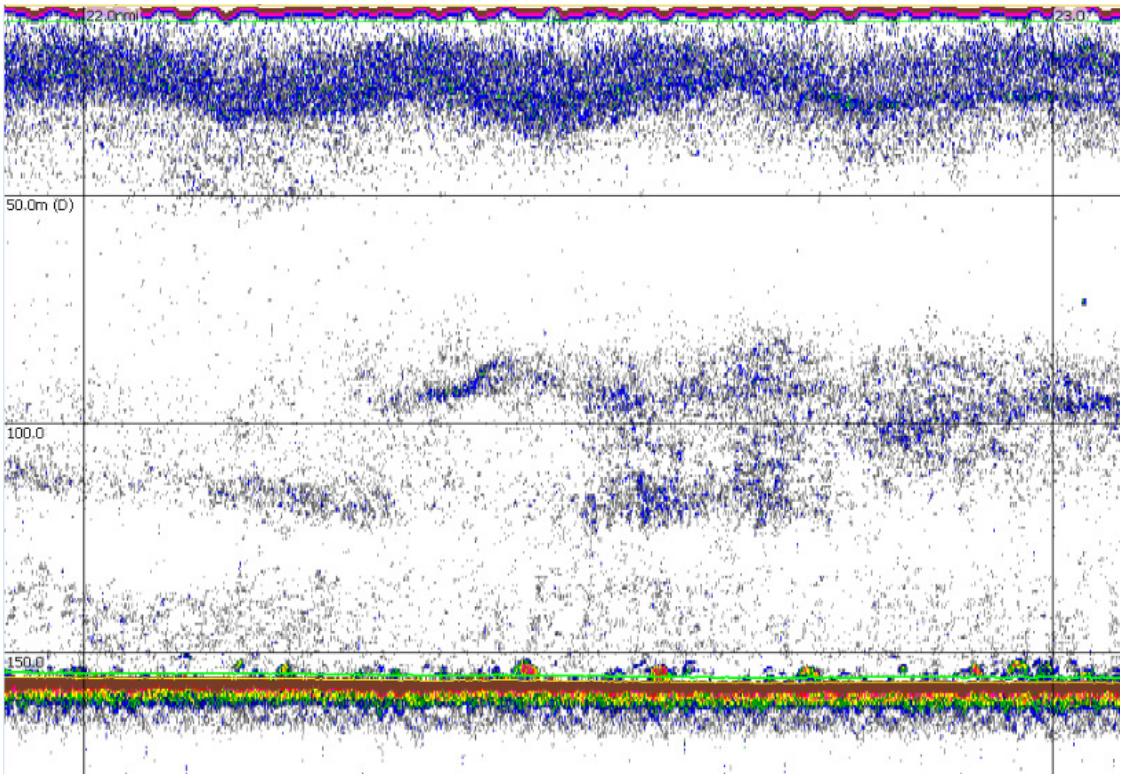
Haul 12. 1/7/14. Large mackerel-like marks seen in stat rectangle 41E1. The marks were not seen on the headline transducer, void haul.



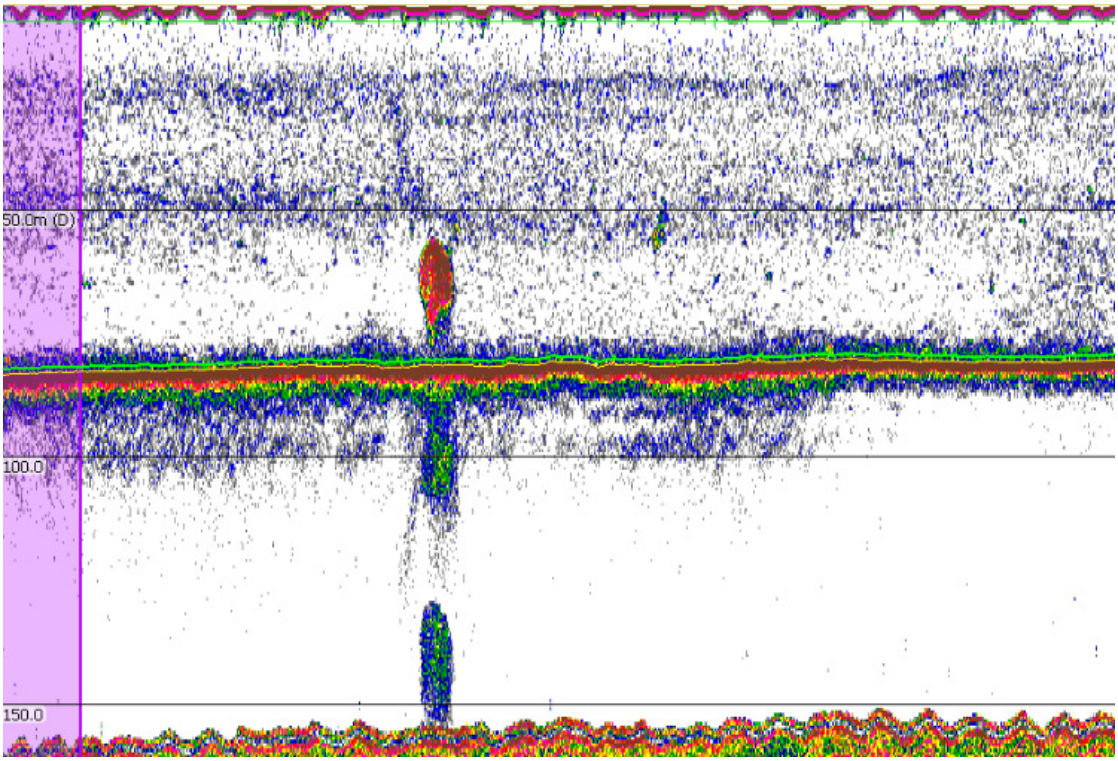
Haul 13. 1/7/14. The smaller these marks in stat rectangle 41E1 yielded 150 kg of herring.



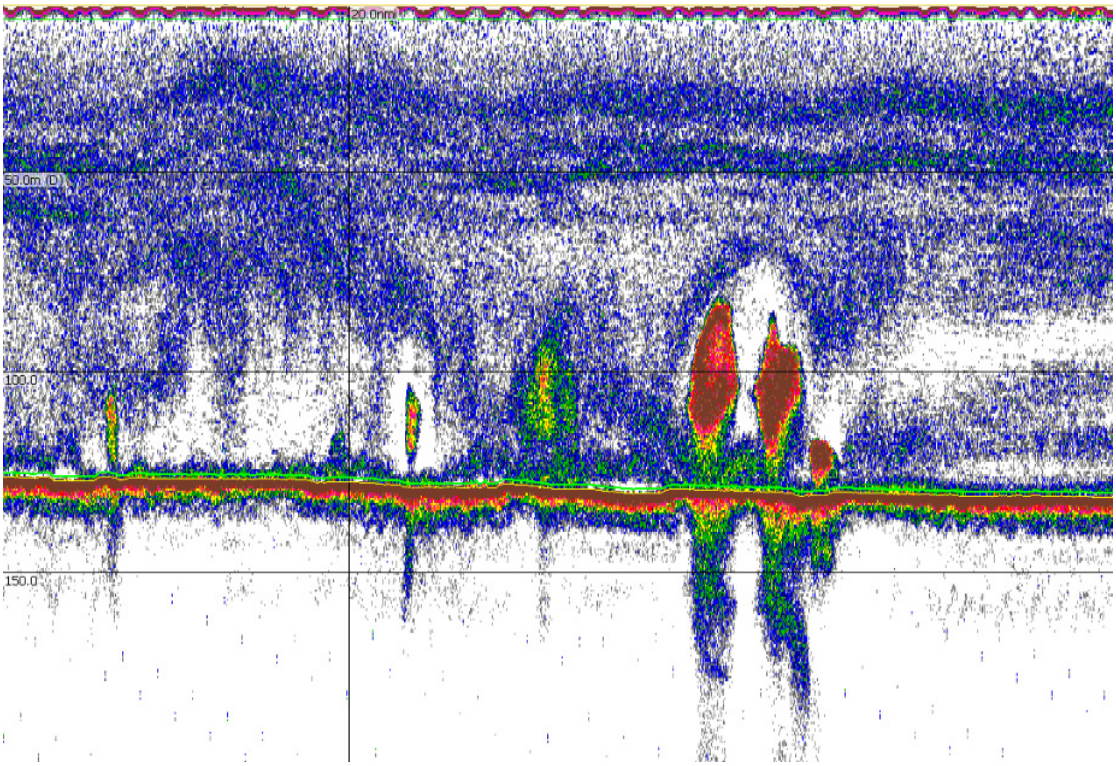
Haul 14. 1/7/14. This mark south of Tiree was not seen again once the fishing gear was in the water.



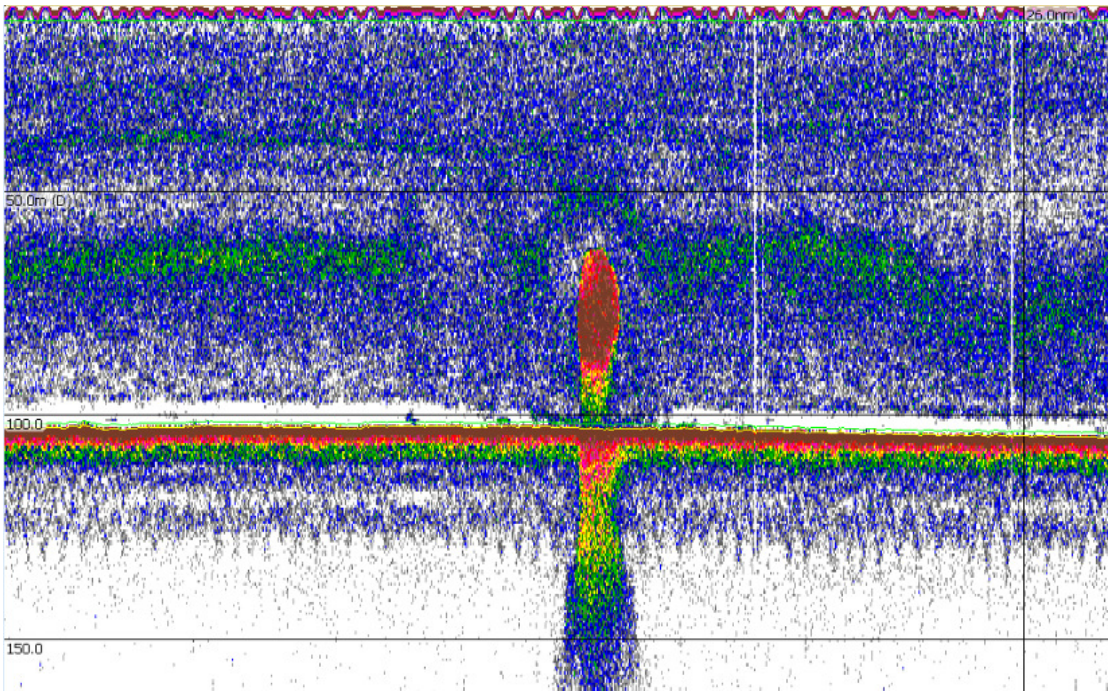
Haul 15. 2/7/14. Almost nothing was in the cod end of the net after towing through this light scattering for 30 minutes.



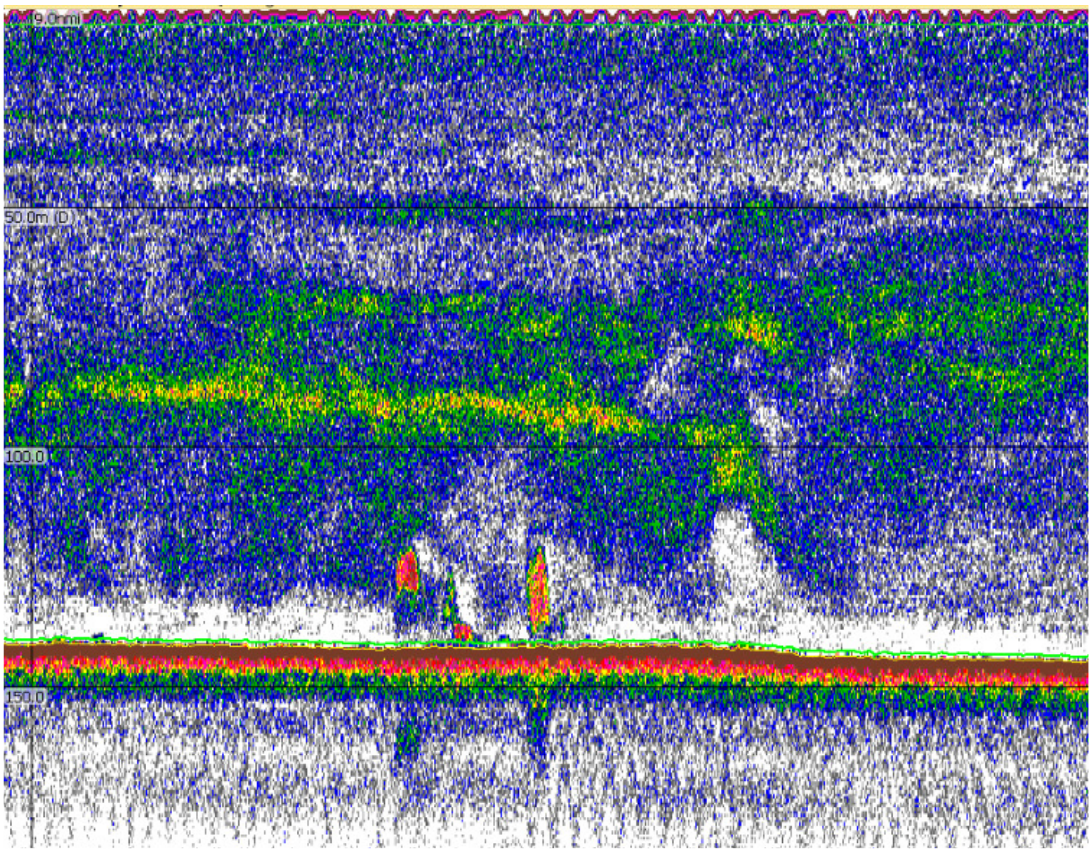
Haul 16. 3/7/14. This large, dense, herring mark south of Tiree contained 1,936kg of herring and 46 kg of sprat.



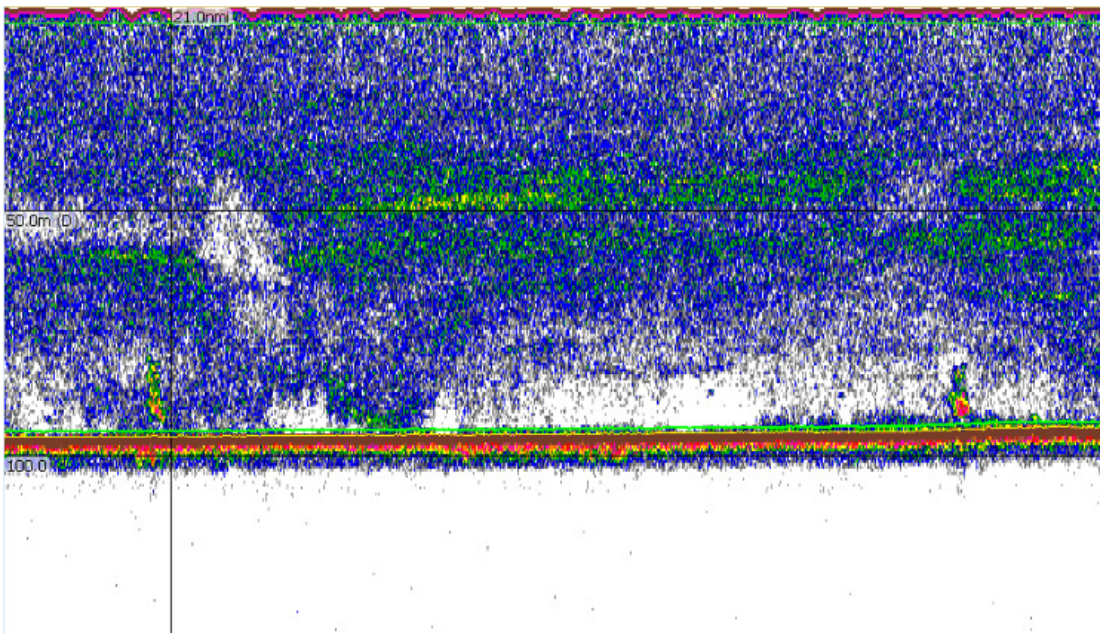
Haul 17. 4/7/14. Despite seeing roughly half of one of these huge marks passing under the headline transducer the net contained just 55kg of juvenile blue whiting. The rest were small enough to escape through the mesh. .



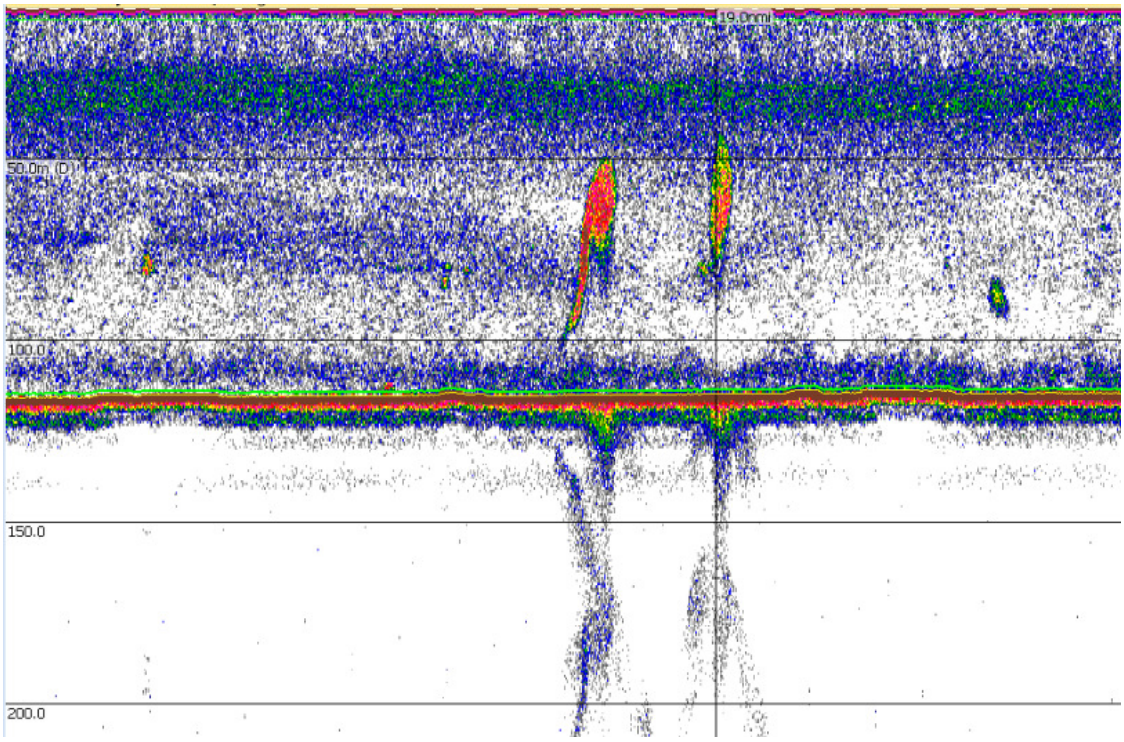
Haul 18. 5/7/14. This huge mark was not seen again once the gear was deployed. Due to its close proximity to the previous haul it is suspected to be also juvenile blue whiting.



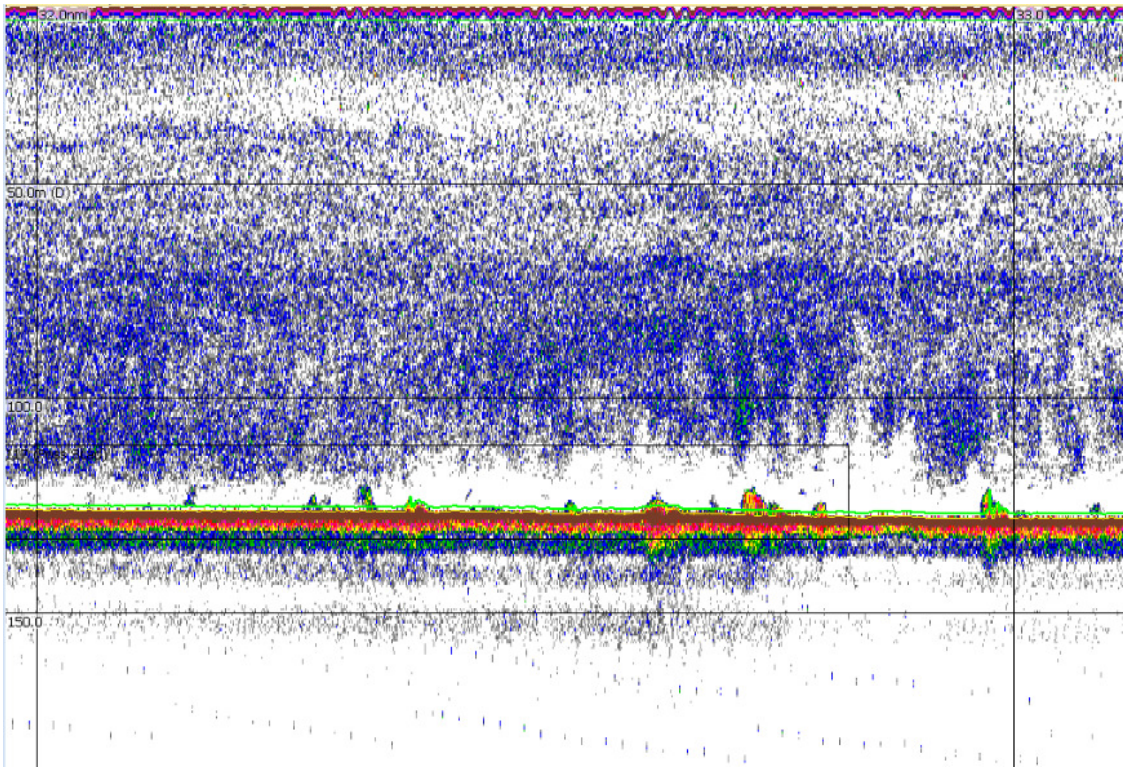
Haul 19. 5/7/14. Marks close to the shelf edge, North West of Donegal. Target was not captured.



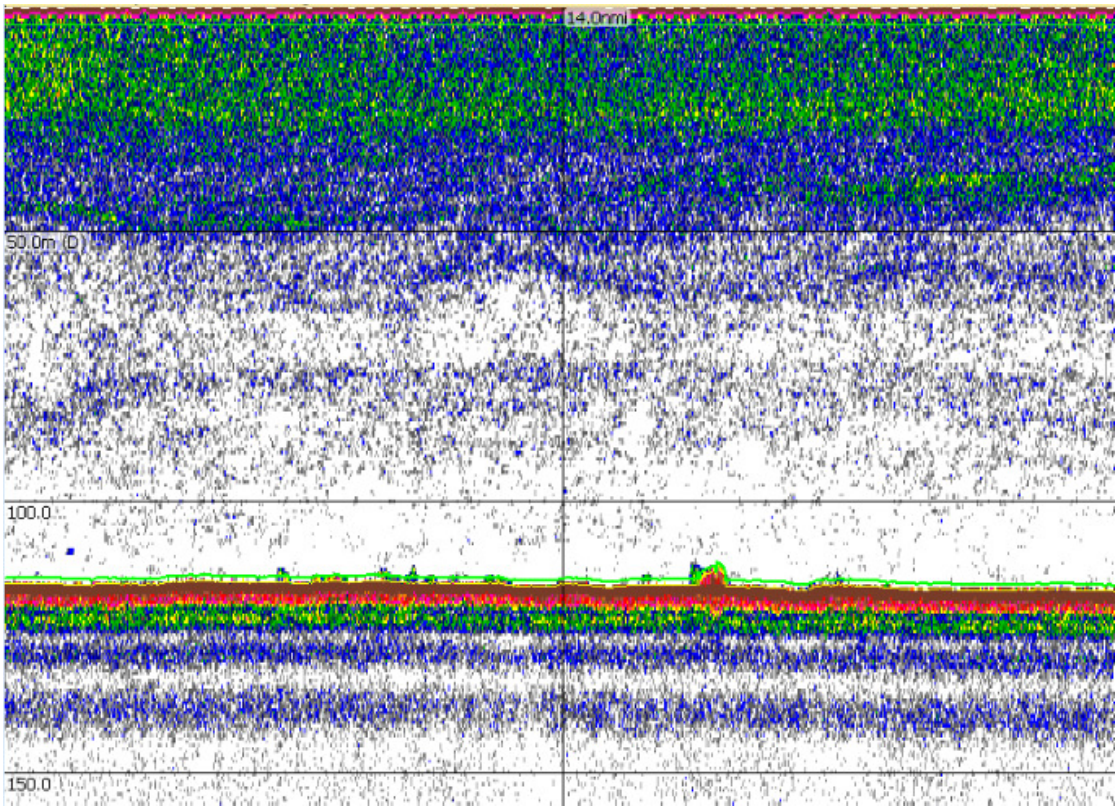
Haul 20. 7/7/14. Two small bottom marks North West of Donegal in stat rectangle 39E1. 48% herring, 43% mackerel.



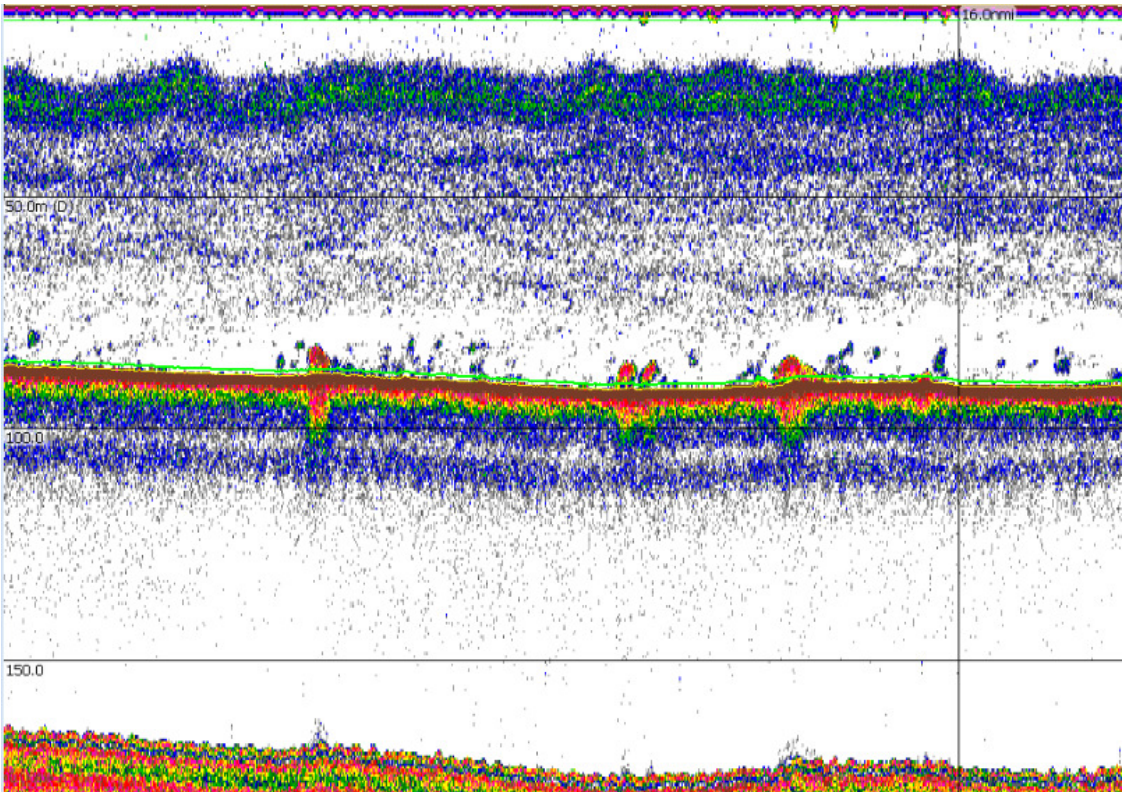
Haul 21 and 22. 8/7/14. Two more huge marks of juvenile blue whiting west of Donegal. These large schools are highly mobile and required a number of passes with the net just to obtain a 50 kg sample.



Haul 23. 8/7/14. A scattering of bottom marks near the shelf edge yielded 31 kg of mackerel, horse mackerel and other assorted species.



Haul 24. 10/7/14. This small mark was not seen again on the headline transducer. Void haul.



Haul 25. 11/7/14. Despite seeing 3 of these marks pass over the footrope west of Inisturk only 10 kg of fish was in the cod end, one third of that being herring.